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INTELLIGENT MACHINE TOOLS

MEGAMARKET IN MEGABIT RAMs

MetaLogic's founders: (left to right) J. R. Southard, Frank Garofalo, and Jeffrey Siskin.

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Cover Photo by Rick Friedman

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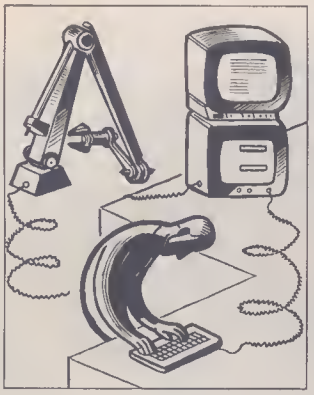

DAVID SUTER

Technology's impact on the workforce

As advanced technology moves into virtually every business and industry, it promises not only gains in productivity but also a flood of problems. Recognizing the trouble ahead is the first step in preparing to meet it.

Industries in every nation are being forced to automate so that more efficient producers elsewhere don't capture their markets. Trade barriers provide only temporary protection for troubled industries and can even make matters worse in the long run: Because they remove incentives for capital improvements, competitors in the rest of the world can zoom ahead.

A few labor agreements may be worked out to protect jobs. But many workers, perhaps millions of them, will still be displaced by automated systems. The results may be even more devastating than the impact of the mechanical revolution on agriculture. Some factory workers will find useful and interesting work in growth industries, but many more simply don't have the skills needed for new kinds of jobs.

A further problem lies with the next generation. In a few outstanding schools, children are gaining knowledge that will help them fit well into tomorrow's workforce. In many places, however, education is lagging. Millions of our youngsters may be totally unprepared for the high tech world of tomorrow.

Accelerating change threatens to create a cultural split even more severe than the scientific/literary schism identified by C. P. Snow a few decades ago. One group will be knowledgeable about new technologies and comfortable working with them. But the other, a huge body of outsiders, will be ill prepared to cope with society's new demands.

Encouraging the growth of innovative businesses, which create jobs much faster than mature industries, is vital. The federal government and most of the states have active programs to accomplish this. But will these technology-based growth ventures be able to find workers with the skills they need? And will the unemployed be capable of handling the jobs available?

Without strong retraining efforts and rapid improvements in our educational system, both answers may be no. There will be a growing population of "unemployables" in our central cities, rural communities, and rust-belt regions, while high salaries, high turnover, and high living become the norm in technology centers.

For a nation based on equal opportunity for all, this is unacceptable. Technology itself, used intelligently, might help provide effective and economical ways to prevent this drift toward a schizoid society. The most critical need, though, is a national commitment to ensuring that all citizens have a chance to learn the skills they require to lead useful, productive lives. The Japanese proved what a national effort can do by achieving uniformly high quality in their once flimsy products.

Let's dig into the problem and solve it.

Robert Haavind

highTechnology

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Center for Research Technology,
Transfer and Trade
Salem, Ore.

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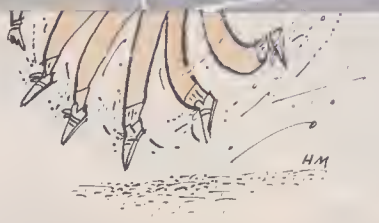
With nuclear plants on-line, utilities have been able to let many oil-fired generators remain idle and keep electric rates much lower than they would otherwise be. If no new coal or nuclear plants are built in



HAL MAYFORTH

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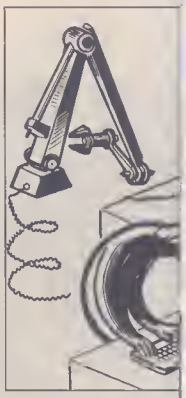
James W. Corbett
East Berne, N.Y.



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LETTERS

Hope for the nuclear industry

"Nukes II" (March 1985, p. 37) was a welcome break in the litany of defeatist antinuclear articles. While not ignoring the problems of the nuclear industry, you left us with a rationale for maintaining the nuclear option. After all, what would high technology be without electricity?

Gilbert J. Brown, Professor
University of Lowell
Lowell, Mass.

Your article on the revival of nuclear power was a particularly thoughtful and well-researched report.

One of the major reasons that nuclear power has run into more trouble in the United States than in other countries was recently summed up by Sir Walter Marshall, an official of the British electric industry. He noted that the British nuclear regulatory agency has a staff of 97 working on reactor licensing, 45 pages of safety guidelines, and no lawyers involved in the basic technical operations. Our Nuclear Regulatory Commission has 1500 employees working on licensing, 3000 pages of safety guidelines, and 110 lawyers.

The U.S.'s problems are largely institutional, and if we want to, we can solve them.

Lynn E. Weaver
Dean of Engineering
Auburn University
Auburn, Ala.

The economics of the nuclear industry are indeed "nettlesome," as you indicate. However, the financial difficulties of the newest generation of nuclear plants should not obscure the fact that this energy source has resulted in cumulative savings to the American consumer. According to a recent study by my company, nuclear electricity has saved U.S. utility customers $30–50 billion over the past decade alone.

Your article notes that "many of the states with the greatest number of nuclear power plants offer the most expensive electricity in the nation, according to the Energy Information Administration." This is misleading. Over 75% of the nation's nuclear generating plants are located in parts of the country that also contain about 80% of the nation's oil-fired generating capacity. This excessive dependence on oil is the primary cause for the high electricity rates in these regions and the chief reason local utilities built nuclear stations.

With nuclear plants on-line, utilities have been able to let many oil-fired generators remain idle and keep electric rates much lower than they would otherwise be. If no new coal or nuclear plants are built in the highly oil-dependent Northeast and Southeast, these regions will be forced to use those idle but available oil plants as electricity demand increases. In that event, oil imports and electric rates will soar, resulting in additional costs to the consumer—about $16 billion a year for increased oil imports alone.

Donnamarie McCarthy, Vice-President
Science Concepts, Inc.
Chevy Chase, Md.

Putting the right foot forward

In your otherwise well-researched and informative article "Running-shoe technology picks up the pace" (March 1985, p. 28), you state that "a typical runner takes about 500 steps per mile." The next day I counted as my left foot hit the ground on a measured half-mile. The number was 298. If you multiply by 2 (for my right foot) and by 2 again (to get the steps in a mile), it's almost 1200! See you on the road.

Patrick R. Parrish
Pensacola, Fla.

Editor's note: The right number depends on how you count your steps. According to Rick Bunch, a biomechanics researcher at Converse, a typical runner takes between 500 and 800 steps per mile—on each foot. *If the steps for both feet are counted, the number of steps per mile comes to between 1000 and 1600, as Mr. Parrish discovered.*

The running-shoe article was fascinating. The pity is that manufacturers don't make comfortable "dress" shoes, since these are worn more often than running shoes.

James W. Corbett
East Berne, N.Y.

Space and society

"Space station: Government and industry launch joint venture" (April 1985, p. 18) was technically competent, and you should be applauded for getting so much so straight. I am distressed, however, at what seems to be a lack of emphasis on—or even a cursory mention of—some of the truly staggering social issues that surround the space station. High technology may be America's fastest-growing business, but it would be a sad mistake to assume that because something is considered technologically feasible and potentially economically viable, it is also socially acceptable.

Some of the issues that deserve consideration: Are techniques of production sole property of the corporation or institution that develops them? If so, does a corporation have the right to suppress information developed on a national installation? Are our allies in Japan and Europe to be given full, free, and complete access to all design parameters and information produced? Do we have unrestricted access to their installations? Will our money be pooled or directed to distinct subsystems? If private industry reaps the benefits of using a space station built with public funds, is it right that profits accrued should be tax-free or tax-deferred?

In the history of technology, there are many examples of programs, built with public funds, that for the noblest of intentions are converted into a morass of industrial, political, and legal intrigue. Do you not owe it to your readers, who are potential investors, to explore some of these problem areas as well?

Adam L. Gruen
Arlington, Va.

Linking R&D with marketing

We, too, believe that the U.S. needs to establish "applied technology centers" for the inventor/entrepreneur in small to medium-sized businesses, as you suggested in your Opinion of March 1985. The lack of innovative marketing strategy is a major problem of R&D and causes it to be ineffective.

H. Griffin Ewing, President
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HAL MAYFORTH

THE "SPIGOT" THEORY OF THE MEGABIT CHIP.

There are megabit chips. And there are megabit chips. All of them can access more than 1 million bits of information. But not all of them can access these 1 million bits of information AT&T fast. And fast to AT&T is 20 million bits per second.

That means we can pour out 1,048,576 bits much faster than you can say "byte." And we can do it because only the AT&T megabit chip has a fast column access mode.

The "Trickle-Down" Theory Vs. The "Spigot" Theory

Most other megabit chips use a "page mode" to access their memory cells. When a chip is in this mode, its fastest data rate is about 10 million bits per second.

But the fast column cycle, developed by AT&T Bell Laboratories, pours out data twice as fast. And not only does data flow out faster, getting data out is easier with the fast column, because access timing requirements are less demanding. Valid data are always available during the entire access cycle.

And speed, ease of use and timing tolerance will make it easier for AT&T to design new and improved products and high-speed systems around the megabit chip.

The Megabit Special

Because this megabit chip is designed for manufacturability, you might want to know what, besides its fast column, makes it special. It's made using an advanced CMOS—Complimentary Metal-Oxide Semiconductor—process that makes it possible to provide high performance at reduced power consumption.

As a matter of fact, it uses 1/8 the power per bit of most 256K DRAMs. The lower power requirement is a plus for any system using the megabit—allowing for lower operating costs and reduced cooling requirements.

Every AT&T megabit chip has more than 2 million elements on it. Among those 2 million-plus elements are more than 20,000 spare memory cells for safety's sake. If for some reason there's a bad cell in a chip, a computer-controlled test targets the cell—and its whole row or column—for replacement. A laser redundancy technique, pioneered by AT&T, then disconnects the offenders and automatically replaces the entire memory row or column from the spares.

Cleanliness Is Next To Goodliness

A speck of dust on a megabit chip is like a boulder on a railroad track.

To keep our chip clean, it has to be made in a room that's C-L-E-A-N. And an AT&T class-10 clean room is one of the cleanest rooms in the world—where the air contains fewer than 10 particles of dust in a cubic foot of air. And the largest particle must be smaller than 1/150 the diameter of a human hair. That makes our room 10,000 times cleaner than a hospital operating room.

To keep our air clean, we have to keep it moving. Ours is constantly circulated and filtered by fans that could inflate the Goodyear blimp in only 30 seconds.

You Ain't Seen Nothing Yet

Looking toward the year 2000, today's technology predicts submicron design widths, with lines only 400 atoms wide. Chips containing 100 million components—50 times the current amount—could have tiny regions with capabilities that more than match the megabit chip.

Now we're talking computer POWER, because these new chips with micro-parts could work at picospeeds (trillionths of a second). Current estimates suggest 10-picosecond transistors.

AT&T will not let the chips fall where they may. We'll put them where they'll do the most good—in the powerful and reliable digital systems creating the general-purpose information technology we call Universal Information Services.℠ Our continuing flow of advanced technology is one reason why AT&T is the right choice.

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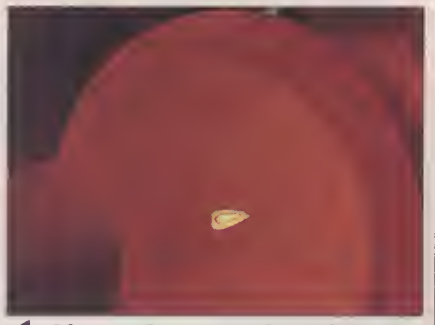
The right choice.

UPDATE

Faster and farther with fiber optics

The promise of lightwave communications glows brighter now, thanks to advances in laser and optical-fiber technologies. The amount of information that can be sent optically depends on how fast the tiny semiconductor lasers can be turned on and off (modulated). While most present lasers flash fewer than a billion times a second (1 gigahertz, or GHz), both GTE Labs (Waltham, Mass.) and AT&T Bell Labs (Holmdel, N.J.) recently reported rates exceeding 10 GHz. And similar speed will soon be available in a product from Ortel Corp. (Alhambra, Cal.). In telecommunication, one 10-GHz laser could handle the equivalent of 300,000 voice channels. Such fast modulation also makes possible fiber optic microwave links. Light, flexible fibers could replace bulky metal waveguides; the substitution would be especially helpful in connecting radar equipment aboard military ships and aircraft, where space and weight are critical.

Optical communication should also benefit from a key improvement in the glass fiber that carries the signal. Present fibers pose a dilemma: The wavelength that travels farthest without becoming undetectably faint is not the wavelength at which pulses can be transmitted in most rapid succession without blurring together. Thus lightwave systems are optimized either for distance or for capacity. A new fiber from Corning Glass Works (Corning, N.Y.) shifts the wavelength of minimum pulse spreading to coincide with the wavelength of maximum transparency (1.55 microns). This fiber enables high-capacity lightwave systems to transmit farther without expensive "repeater" stations.



◀ *Glass rod emerges from furnace before being drawn into ultraclear communications fiber.*

CORNING GLASS WORKS

Ford bets that gallium arsenide is a better idea

Ford Microelectronics, the auto giant's Colorado Springs chip-making subsidiary, plans to occupy by autumn a new $33 million plant for fabricating gallium arsenide (GaAs) integrated circuits, which operate faster and are more radiation-resistant than chips made of silicon. Some 15–20 GaAs specialists—with the assistance of the company's silicon chip designers—are already fine-tuning production equipment, training operators, and cranking out GaAs test chips on a prototype production line set up in rented quarters, says marketing manager Charlotte Diener. She reports that the plant's first product, scheduled to reach the market in early 1986, will be a gate array chip (designed to be customized for small-volume applications) but adds that 1K and 4K static random-access memory chips are also under development.

Ford is targeting high-volume markets for data processing, telecommunications, and instrumentation equipment, although its charter also includes supplying small quantities of specialized GaAs chips for sister company Ford Aerospace, a major defense contractor. Diener acknowledges that building a merchant GaAs semiconductor house—when technology for using the material is still struggling out of research labs—could take years and vast sums of money. "We have a strong financial parent used to the automotive industry's long product development cycles," she says. "They know what it's like to invest money and wait years for a return."

Software simulates automated factories before they're built

A software package called Modelmaster lets engineers simulate the operation of automated factories that are still in the blueprint stage. Offered by General Electric's Automation Controls Department (Charlottesville, Va.), the software is the outgrowth of programs that GE has developed during the past several years to design and modernize more than a dozen of its own plants.

Modelmaster, which runs on a variety of computers, initially displays a grid pattern that is scaled to the dimensions of the target facility. Using the terminal keyboard or a mouse, the engineer places different icons—representing robots, forklifts, and other common equipment—at the proper locations and then indicates the paths of the material-handling systems. After the physical layout is established, the computer queries the designer about such operational parameters as processing time for each station and transit times between stations, as well as about likely maintenance and repair downtimes.

Once the facility's cycle time has been defined, the user can simulate its operation for as little as one shift or as long as several months. The software displays the facility in animated operation, produces summary statistics, and can generate related graphics that show, for instance, production bottlenecks.

UPDATE

Shield blocks VDT radiation

A shield that reduces by 98% the amount of low-frequency electromagnetic radiation emitted by cathode-ray tubes in video-display terminals (VDTs) has been developed by Sentinel Bio-Tech (Hyannis, Mass.) and Mitsubishi International (Tokyo). Known as the Sentinel VDT BodyGuard, it consists of a stainless steel mesh sandwiched between two acrylic sheets; it is placed in front of the VDT screen and connected to a ground wire that drains the radiated energy. The shield also enhances visibility of the VDT screen and cuts down glare.

Sentinel is now marketing the product for $160–$250, but much controversy has arisen over whether such low-frequency radiation is actually harmful. Charlotte LeGates, communications director of the Computer and Business Equipment Manufacturers Association (CBEMA—Washington, D.C.), claims that the VDTs do not emit harmful radiation and that studies indicating the contrary have not undergone proper peer review. CBEMA is not opposed to screens that reduce glare, she says, but the group fears that people will be misled by "companies advertising that they have a screen that blocks radiation as if there were any harmful radiation."

Meanwhile, researchers such as Hari Sharma of the University of Waterloo (Ontario) claim that VDT emissions, if unabated, seem to cause birth defects, miscarriages, stress, and other health problems. Radiation level varies from terminal to terminal and depends mostly on the effectiveness of the machine's casing. Sharma has tested a variety of shields like the BodyGuard and maintains that Sentinel's device is the most effective he has encountered.

Wind turbine exploits Venturi effect

A vertical-axis wind turbine said to be three times as efficient as conventional propeller turbines has been developed by the Herrmann Rotor Co. (Chicago). Called the Venturi Rotor, the machine consists of a cylindrical spoiler (wind barrier) with three aerodynamically shaped airfoils turning about it. As each airfoil passes across the wind, it swings outward like a sail, capturing air reflected by the spoiler. The outward movement also narrows the space between the airfoil and the spoiler, causing air to flow through the gap at high velocity—the Venturi effect—and creating a low-pressure zone in front of the airfoil. The combination of high air pressure on one side of the airfoil and suction on the other generates a strong torque on the central shaft. Because the Venturi Rotor has a long torque arm, winds of only a few mph from any direction will cause it to turn.

Unlike a propeller turbine, the Venturi Rotor has no gears and thus requires no lubrication and little maintenance, says inventor Christian Herrmann. At high wind speeds, centrifugal force causes the airfoils to swing out and act as brakes; a prototype rotor with a span of 16 feet withstood tornado winds of 160 mph without damage.

The Venturi Rotor should sell for about $75,000, including generator—three times the cost of a propeller turbine of equivalent size. For a power-generating station, several Venturi Rotors would be stacked on a multilevel platform 170 feet high. In locations where the average wind speed is 40 mph, Herrmann claims that such stations could produce 7.5 megawatts of power, at a cost below 1¢ per kilowatt. But Forrest Stoddard, a wind-energy consultant in Amherst, Mass., doubts that the Venturi Rotor would be economical at lower average wind speeds.

Inventor Christian Herrmann with a prototype of the Venturi Rotor wind turbine.

Managing R&D in industry

by David C. Hill
VP for R&D, Chemical Sector
Allied Corp.

Successful research and development efforts in industry don't just happen. They are brought about by the effective management of programs tailored to a company's strategic plan. What works for one company, of course, is not necessarily useful for another. Nevertheless, there appear to be four principles that can assist executives in choosing the R&D programs most appropriate to their firms.

The first principle is to look where the rules are changing. Whether it be technological, economic, or social, change creates opportunity. The rapid price increases for energy and feedstocks in recent years, for example, produced major industrial innovations in energy conservation and yield-improvement programs, with consequent rises in productivity. Even though the shocks of higher energy costs were at first painful, they forced us to reexamine our design philosophies. In doing so, we learned how to use existing capital more effectively.

In the chemical industry today, the rules are changing on several fronts. Our customers in the electronics industry, for example, are demanding purer chemicals for integrated circuit production. The drive for higher packing densities has pushed resolution requirements down to 1 micron, where even the slightest trace of dust can have a disastrous effect on yields. Society is demanding pesticides and herbicides with greater environmental acceptability; analogs of naturally occurring chemicals such as pheromones and pyrethrins, perhaps made through biotechnology, could provide the answer. Similarly, solutions to the waste disposal problems that face industry and municipalities are a high priority.

Change is pervasive. From the information revolution to the decline in birthrate, each shift suggests new markets and growth potential. Probably the worst mistake an R&D manager can make is to spend disproportionate sums of money on refinements of already mature products and processes—a strategy doomed to pay fewer and fewer dividends over time.

The second principle is to build on strength. Technological achievement is difficult enough without having to simultaneously develop a market presence in a new field; a company improves its chances for success by formulating its R&D program to emphasize a product or market it already understands. And the more elements of strength that are present—such as raw materials, marketing sophistication, technical expertise, or management skill—the more likely that the program will succeed.

The third principle is to focus. There are many forces that tend to diffuse and misdirect resources: the desire to address a broad range of problems, the diverse interests of the staff, and the pet projects of senior management, to name a few. In some laboratories there are more programs than researchers. But experience shows that the best results are achieved when the elements of the R&D portfolio are carefully chosen and well coordinated.

Such focus does not have to come at the expense of variety or creativity. The laboratories of Du Pont, GE, Exxon, and Allied, for example, undertake projects of widely varying time horizon and degree of technological risk. Generally, these programs build on corporate strengths—such as polymer science and fluorine chemistry at Allied—to focus on areas of technology already of significance to the company. But new directions, such as life sciences at Du Pont or microelectronics at GE, can also show promise when many of the ingredients for success are already in-house.

The last principle is to stick to the game plan. Every R&D director is painfully aware of the effect of the business cycle on his budget. In good times, corporate support is easy to come by; in bad times, R&D can be seen as a discretionary expense. Add to this the inherent difficulty of gauging progress in an R&D project, and there can be real trouble when the cycle turns down.

Managers accustomed to sales forecasts, production quotas, and economic models often find it difficult to understand that the R&D program may be on the right track even though major breakthroughs aren't occurring every month. But executive confidence is essential if R&D is to succeed; company leaders must understand that although invention can't be programmed, the probability of eventual success is high if the projects have been carefully chosen. Allied's major diversification into materials and GE's highly successful move into engineered plastics came about because of senior management's continued support through both good and bad times.

The technological edge that the United States has held so long is fast eroding, and R&D efforts are essential to reverse this trend and reestablish the country's position. But although the above principles will help individual companies improve the planning and execution of their own R&D, firms are limited in what they can accomplish by themselves. Cooperative R&D—the joint pursuit of mutual technological goals by several companies—is already a fact of life in Japan's highly developed planning system. American law has impeded such collaboration, but the government's attitude is beginning to change in recognition of the improved research climate, efficient use of resources, and ultimately enhanced general productivity that cooperative R&D allows. The electronics industry is leading the way. Let us hope that its success will encourage similar ventures in other sectors of the American economy. □

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Intel:

PLUNGING INTO PARALLEL PROCESSING

Intel's new hypercube computer is in the bailiwick of VP Ed Slaughter, head of the company's development operation.

KEITH SKELTON

Despite its reputation as a pragmatic, market-driven company that thrives on large-volume manufacturing, microchip maker Intel (Santa Clara, Cal.) set up a new division a year ago to produce the iPSC, a computer with such unconventional architecture it requires a whole new approach to programming. Linking as many as 128 microprocessors in a configuration called a hypercube, the machine could take years to graduate from experimental status. But if all goes well, and if the company can successfully encourage users to create software, the iPSC could become one of the first commercial "massively parallel" computers (machines in which large numbers of processors work on a single problem).

Scheduled for a late June debut, the iPSC will be targeted at universities and research labs that need high-powered number crunching for scientific and engineering simulations but can't afford to buy a multimillion-dollar supercomputer. These first versions, to be priced from $150,000 to $520,000, will be low-powered "learning" machines, say company officials, but more powerful models will follow.

Unlike most computers, which have one central processor attached to a single memory bank, the iPSC has many "nodes," each containing a general-purpose microprocessor (Intel's most powerful, the 80286), a numeric processor, and two dedicated memory chips. In a 32-node version, each node connects directly to its five closest neighbors; in a 64-node version, to its six closest neighbors; and in a 128-node version, to its seven closest neighbors.

The hypercube design was developed at Caltech with funding from the U.S. Departments of Energy and Defense. Justin Rattner, general manager of Intel's Scientific Computer division (which makes the iPSC in Beaverton, Ore.), was so taken with the hypercube on a visit to Caltech that he convinced the company to license the design and commercialize it.

Although iPSC software is very different from conventional programs (which progress through a single string of commands, one by one), it is well suited to simulating physical processes and natural phenomena, contends Ed Slaughter, VP and general manager of Intel's development operation (which oversees the Scientific Computer division). For example, metal under stress is subject to many independent but simultaneous forces, each of which interacts most with others in close proximity. Simulating this process on an iPSC, says Slaughter, results in "a natural fit" with the near-neighbor connections among the machine's nodes.

These similarities may make learning the new approach to programming easier for physicists and chemists than for computer scientists, Slaughter conjectures. But unless Intel upgrades the learning-version iPSC with a model that "has eye-popping power," says Kenneth Wilson, director of Cornell University's Center for Theory and Simulation in Science and Engineering, physicists and chemists "won't be willing to go the extra mile" to program it. To avoid this problem, several competing companies are pursuing less radical software strategies. For example, the number-crunching machine developed by Convex Computers (Richardson, Tex.) is software-compatible—to an extent—with minicomputers from Digital Equipment, and the machine developed by Scientific Computer Systems (Wilsonville, Ore.) is software-compatible with supercomputers made by Cray Research.

Thus, short of giving the iPSC irresistible power, Intel had better be prepared to lend a hand with "the intense problem" of developing software, warns Sidney Fernbach, a consultant formerly in charge of computation for Lawrence Livermore Labs (San Jose, Cal.). "Somebody is going to have to stick his neck out—or stick his money out—and write software," he says, "and I'm not sure Intel is prepared to do that." Although Intel is a world leader in semiconductors—reporting 1984 profits of $193 million from $1.6 billion in revenues—its previous excursions into the computer systems business (with office-oriented microcomputers) were less than spectacular. Establishing a top-flight software group is a tall order, especially given that Intel officials predict a slow year overall because of the semiconductor industry recession.

However, Intel's Rattner reports that the Scientific Computer division is already recruiting programmers to work under the leadership of Cleve Moler, formerly chairman of the Uni-

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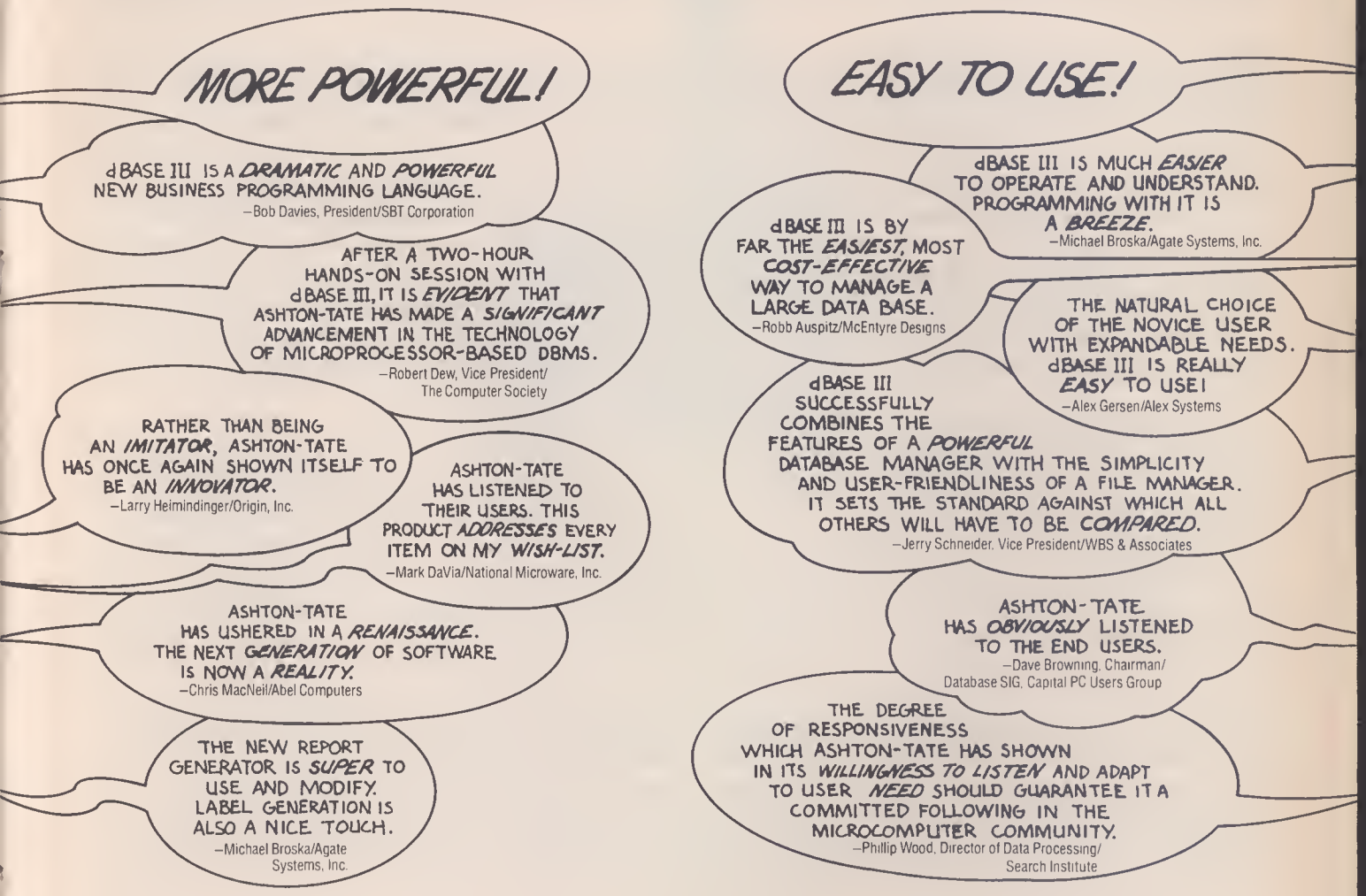

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SCIENCE/SCOPE

In the 25 years since the birth of the world's first laser at Hughes Research Laboratories, the "light fantastic" has grown from a laboratory curiosity into an indispensible tool in medicine, industry, electronics, data processing, communications, and scientific research. That first laser, built by Dr. Theodore H. Maiman, was operated on May 15, 1960. It used a flash lamp coiled around a solid ruby crystal to produce an intense pulse of red light with a wavelength of precisely 6943 angstroms. Lasers today employ various gases or crystals and operate throughout the electromagnetic spectrum. They are used as tools for cutting, welding, drilling, and marking metals; as alignment and measuring devices; as the sources of signals in fiber-optic communications systems; and as rangefinders and target illuminators in military systems. Promising new medical uses include advanced eye surgery techniques, internal cauterization, and treatment of cancer. Already used in some computer printers, lasers one day will be widely used in high-speed optical computers to process and store data.

An advanced computer system for air traffic control is being designed to serve the U.S. into the 21st century. The new Advanced Automated System (AAS) will consolidate existing en route facilities and approximately 130 terminal facilities into 23 area control facilities throughout the country. It will automate many routine air traffic control activities now done manually. Computers will monitor and evaluate air traffic situations and offer solutions to potential conflicts between airplanes in flight. AAS will include controller consoles to display radar data, weather information, and flight plan data; powerful modern computers; and new software to run the new system. Hughes is designing AAS for the Federal Aviation Administration under a competitive contract. Hughes has built air defense systems for more than 20 nations, including the U.S., Canada, and NATO countries.

The first full-scale development AMRAAM missile was fired successfully at the White Sands Missile Range in New Mexico. The missile was launched from a U.S. Air Force F-16 at 40,000 feet at a speed of Mach 1.2. It flew a preprogrammed course designed to evaluate the missile's control system and separation from the launch aircraft. It did not have a seeker but instead was programmed through its autopilot to fly a prescribed route. The Advanced Medium-Range Air-to-Air Missile is in full-scale development at Hughes for the U.S. Air Force and Navy.

An advanced factory management system model, developed by Computer Aided Manufacturing-International and Hughes, will help optimize use of manufacturing resources. The model will address interactions of all work areas within every level of the organization. It will precisely identify department production capacities, queue bottlenecks, and resource flow. Managers now must make decisions without knowing all interactions among workstations, cells, and departments.

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HUGHES
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versity of New Mexico's computer science department. And he notes that software developers aren't starting totally from scratch; some application programs (in computer science, physics, and aerodynamics) were written for the original hypercube computers at Caltech. These will all run on the iPSC with only minor modification.

Problems aside, Intel has already garnered a firm order for the new machine—from the Yale University computer science department. And even skeptics voice admiration both for the computer's inventive design and for Intel's pioneering spirit in parallel processing. "Somebody's got to break the ice," says consultant Fernbach. "I respect Intel for taking the plunge."

—Sarah Glazer

Showing managers how their choices stack up is the aim of Decision Support Software's program, says president Mary Ann Selly.

Decision Support Software:

A PROGRAM TO STEER THE SHIP OF STATE?

What single "expert" do the White House, the Internal Revenue Service, the World Bank, the National Security Agency, and all four branches of the armed services consult for help in making decisions? It's a personal computer software package called Expert Choice, sold by tiny, privately owned Decision Support Software (DSS) in McLean, Va. The package is helping these government offices allocate staff time, plan internal budgets, and choose office equipment and contractors. By targeting the federal government, DSS has carved a small but lucrative market niche for itself in management software—packages designed to help executives make decisions that range from hiring staff to choosing office sites.

Although DSS sold only 1000 copies of its $495 package from May 1984 (when the program became available) until the end of the year, half went to the government and military. This statistic may have more to do with the background of company president Mary Ann Selly than with the package's contents. Previously on the technical staff of defense contractor Mitre Corp. (Bedford, Mass.), Selly worked on projects for computerized military intelligence systems and routinely dealt with high-ranking government officials. The federal government is a virtually untapped market for management software, she believes.

Expert Choice is based on hierarchical mathematical theories developed by Thomas Saaty, a math professor at the University of Pittsburgh, and Ernest Forman, a management science professor at George Washington University. Forman, now R&D director for DSS, teamed up with Selly in 1979 to do computer consulting, and the two decided to form their own company. Expert Choice is but the latest in a series of DSS software products, which also include accounting programs for the home and small businesses. The company is self-funded, and its principals say they have no plans to take it public.

Like DSS, most sellers of management packages—including Thoughtware (Coconut Grove, Fla.), Lightyear (Santa Clara, Cal.), and Human Edge Software (Palo Alto, Cal.)—are small privately held companies. According to market research firm Future Computing (Dallas), they sold about 150,000 units worth $22 million in 1984, and totals should increase to 263,000 units worth $40 million in 1985.

However, sales may not improve dramatically unless vendors convince upper-level executives, who tend to shy away from working directly with computers, that their products are useful tools. A more fundamental problem, says William Weil, technical services director for Ferrin Corp., a San Francisco microcomputer consulting company, is that management software forces users to follow standard, predetermined lines of reasoning. "Decision makers don't follow a conscious methodology," he says. But Selly maintains that Exxon considered Expert Choice valuable enough to bring into the corporate boardroom to help top brass hammer out specific solutions to problems. The program can also help managers justify their decisions to company higher-ups, observes James Kaslik, senior operations research analyst for Air Products and Chemicals (Allentown, Pa.). The industrial chemical company has used the package for more than a year in such applications as selecting the best advertising media for a new product introduction. Other corporate customers include IBM, AT&T, Citibank, Digital Equipment, and Westinghouse.

DSS is trying to rise above the skepticism about management software by emphasizing customer education. It identifies the basics of decision modeling in seminars given in conjunction with universities. For additional sales, it relies on a handful of knowledgeable dealers (particularly in California and in the Chicago and Washington, D.C., areas) to explain the package. "It's a slow sell," admits Selly, "but already we're seeing repeat sales."

Undaunted by slow market acceptance, DSS is considering additional decision support packages. These may be tailored for such decisions as choosing a car, office, career, or new home. Or they may include modeling "templates" of common business decisions to help novice users. The company also intends to keep its focus on the federal government—not just because Expert Choice can help with ordinary administrative problems, but also because DSS hopes the package might someday aid in the weightier decisions and negotiations that guide U.S. policy.

—Mary Jo Foley

Denning Mobile Robotics:

ROBOTS GUARD THE PEN

Within a year, platoons of guards that each stand 44 inches tall and weigh 385 pounds will begin roving the drab corridors of prisons. These machines are the brainchild of Denning Mobile Robotics (Woburn, Mass.), a 26-employee firm formed three years ago to develop security robots. Earlier this year, Southern Steel of San Antonio, one of the nation's largest prison suppliers, signed an exclusive contract with the company, agreeing to buy

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520–680 of the robots for $23–30 million over the next three years.

"Initially, they will be used in conjunction with human guards," says John Harding, Denning's VP of operations. "By the third or fourth generation, they will probably work alone." One human guard teamed up with a robot can take the place of three or four ordinary prison guards.

Until now, commercial robots have primarily been bulky, large-armed machines designed for factory automation. The only mobile industrial machines that have been in operation are carts that follow a painted line or an underground cable. Robots with greater mobility are in essence still toys and mainly serve hobbyists. But Denning's Sentry, which combines existing technology with new software and a customized guidance system, may change that pattern.

Company executives targeted the security industry after conducting an in-house market study, which estimates the potential annual business to be worth about $5 billion. Frost & Sullivan, a New York market research firm, pegs the security business at an even higher $8.8 billion a year.

The standard Denning Sentry—not the special prison guard version—is designed to work alone or with human guards. It performs indoor patrols of one-floor minimum-security facilities—such as factories, warehouses, and cafeterias—where a typical concern is vandalism. The robot (which resembles *Star Wars*' R2-D2) moves in smooth arcs and can calculate its way back to its normal route after detouring around unexpected obstacles.

VPs Elaine Schubert and Benjamin Wellington, president R. Warren George, and VP John Harding stand guard with the Denning Sentry.

It can travel as fast as five miles an hour, synchronizing its three-wheel independent drive and steering systems, which are powered by three rechargeable 12-volt batteries.

For navigation, the robot relies on a series of Polaroid ultrasonic sensors, infrared tracking beacons, microwave radar, optical-range devices called cat whiskers, and special mapping software. Brainpower comes from a Motorola 68000 microprocessor, communication power from a radio link, and fire-sensing ability from smoke and temperature detectors. The robots, priced at $64,000, will be manufactured and maintained by Raytheon Service (Burlington, Mass.). Although Denning wants to avoid extensive customizing, it will make variations if the purchase order is large enough, says Denning's Harding. For instance, the prison guards will be able to see, hear, and speak by virtue of closed-circuit television cameras, microphones, and loudspeakers.

To develop the robot, Denning raised $3 million through a public stock offering in the summer of 1983 and promptly sunk the $2.5 million in net proceeds into research. In order to supplement the efforts of Denning's small staff, the company established research affiliations with two of the country's leading robotics research centers: MIT and the Robotics Institute of Carnegie-Mellon University. For example, robotic scientist Hans Moravec of Carnegie-Mellon serves on Denning's board of directors and acts as a part-time consultant. Analyst Denise Soranno of Baird, Patrick & Co. believes the R&D investment is paying off. "The applications for their robot can be endless—even in warehouses alone," she says.

At this stage, though, the robot still has limitations. It can't climb stairs, use elevators, or ride escalators, and it can't work outside. Moreover, its outer shell of fiberglass won't withstand severe blows or bullets. But with the first large sale on the horizon, company president R. Warren George II anticipates future improvements and additional contracts with the security industry. He is also eyeing other potential markets that range from nerve gas disposal and hazardous waste handling to floor washing at malls. If plans materialize, the company could become one of the first to mass-produce mobile robots, he says. "George Lucas [director of *Star Wars*] was there first, but maybe we can make it a reality." ***—Elizabeth Willson***

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CHIP DESIGN MADE EASY

A new generation of tools enables nonexperts to design custom integrated circuits cheaply and quickly

♦ by Jeffrey N. Bairstow ♦

Newly developed design automation systems are slashing the costs and reducing the time needed to design complex integrated circuits (ICs). The combination of powerful engineering workstations and novel software tools is making custom chip design economical even for engineers without training in the specialty. By enabling the rapid and routine design of special-purpose ICs, this fast-growing technology—called computer-aided engineering (CAE)—may eventually render standard-component ICs obsolete, thus revolutionizing the semiconductor industry.

Not much more than a decade ago, engineers designed large electronic systems with tens of thousands of discrete transistors mounted on cumbersome printed circuit boards. With the advent of integrated circuit technology that allowed dozens of transistors to be grouped on silicon chips, fewer printed circuit boards were needed, and systems could be housed in smaller enclosures. Today, complex systems can be designed with very-large-scale integrated (VLSI) circuits containing as many as

RICK FRIEDMAN

half a million transistors on a single chip. But the conventional method of designing such circuits is extremely complex, requiring teams of highly skilled and experienced designers and, often, years of effort.

Until very recently, therefore, only the promise of enormous demand for a specific VLSI chip, such as a microprocessor, could be expected to produce a satisfactory return on investment. Hence system designers have had to build hardware from off-the-shelf ICs, because semiconductor manufacturers could not afford to build application-specific integrated circuits (ASICs) on a custom basis. At the same time, however, market pressures for increased functions and smaller packaging at lower costs have been causing the demand for ASICs to mushroom.

The availability of new automated-design technology, prompted in large part by the changing market dynamics, is altering the economics of designing and building ASICs. According to the market research firm Dataquest (San Jose, Cal.), the market for ASICs will be $14.9 billion, or roughly a third of the total IC market, by the end of the '80s—an astounding growth for a market that barely existed earlier in this decade.

Application-specific ICs produced by automated design tools are already beginning to appear in commercial products. For example, the new MicroVAX computer from Digital Equipment Corp. (Maynard, Mass.) is built on two printed circuit boards totaling only 158 square inches, or about a fifth the size of a comparable VAX computer designed the conventional way. Much of this size reduction is due to the MicroVAX's datapath VLSI chip, which is almost an entire 32-bit microprocessor. Using a prototype tool called a silicon compiler (see "Compilers: a high-level approach to IC design," p. 20), a three-person design team produced this 37,000-transistor IC in only seven months. By contrast, using conventional design methods for a full-custom VLSI chip, the MicroVAX chip would have taken more than seven person-years, or about four times as long. (A generally accepted rule of thumb is 5000 transistors per person-year.)

Solomon Design Automation president Jim Solomon (opposite page): "Automating chip design is the Manhattan Project of CAD—it's probably the only way we'll head off the Japanese threat to take over the integrated circuit business."

Mentor Graphics executive vice-president Gerry Langeler (above): "Our customers' appetite for integrated circuit design automation is insatiable. We've solved the easy problems; now we have to tackle the tough ones."

Not only do full-custom ICs normally require large design teams and many years of effort, but there simply aren't enough skilled IC designers available to devote to application-specific chips. By some estimates, there are only 2000–3000 experienced integrated circuit designers in the world, versus 300,000–400,000 system designers. According to industry estimates, though, perhaps 50% of those system designers could design their own ASICs, given the appropriate design tools.

Most ASICs in use today are not designed as full-custom chips. The most common style is the gate array, a device made up of several thousand primitive logic gates whose interconnections can be defined by the user. Because gate arrays are predefined, they are rarely efficient in their use of silicon. As gate arrays get larger, they become even less efficient, since more gates go unused and more of the silicon area is devoted to the metal interconnections between gates.

Nonetheless, industry experts estimate that in 1984 system engineers completed more than 2500 gate array designs. Moreover, since most aspects of gate array design can be automated, and since efficient tools already exist, that figure is expected to grow rapidly. The three major CAE workstation manufacturers—Daisy Systems (Mountain View, Cal.), Mentor Graphics (Beaverton, Ore.), and Valid Logic Systems (San Jose, Cal.)—all offer gate array design systems, as do several silicon foundries (companies that fabricate custom chips), such as VLSI Technology (San Jose, Cal.) and LSI Logic (Milpitas, Cal.).

For example, Daisy's Gatemaster is based on the company's well-established Logician series of workstations. The software handles schematic design entry, logic circuit simulation, signal-timing check, generation of circuit-testing routines, and physical layout of the silicon chip. According to Daisy, the system supports over 50 libraries of gate array designs from more than 25 silicon vendors. For gate array vendors, Daisy offers the MegaGatemaster, a powerful 32-bit workstation with significant simulation capabilities and an additional microprocessor to handle floating-point arithmetic.

A rapidly growing alternative technology for ASICs is the standard cell approach. Standard cells are predesigned functions such as logic gates, memories, programmed logic arrays, and even microprocessors. The cells are of fixed size and are available to users from a library of functions. A designer selects the logic elements called for in a design and places them, often using the standard cell vendor's own tools, to get the best use of the silicon area and the most logical and efficient interconnections. From the designer's layout, the semiconductor manufacturer combines the cells and produces the chip.

As with gate arrays, all the leading workstation makers offer standard cell tools and libraries. For example, the Mentor Graphics Cadicell software package automates the standard cell

Compilers: a high-level approach to IC design

The silicon compiler appears to hold out the greatest hope for significant automation of VLSI chips for system designers. It produces sets of instructions that can be used, in conjunction with other software tools, to produce masks for chip fabrication.

VLSI Technology, Inc., and Seattle Silicon Technology (SST) have developed relatively complex cell compilers that can be described as silicon compilers, but the first company to market a true silicon compiler is Silicon Compilers, Inc. (SCI). Its product offers the generation of system-level simulation models and the automatic interconnection of compiled modules.

SCI's method of silicon compilation leans heavily on the hierarchical IC design technology developed by Carver A. Mead, a professor at Caltech, and Lynn Conway, former manager of VLSI systems research at Xerox's Palo Alto Research Center. The first compiler—called Bristle Blocks, because it was designed to interconnect cells with predefined input/output patterns—was built by David L. Johannsen, one of Mead's graduate students.

Johannsen became a cofounder of SCI, along with Philip A. Kaufman, former general manager of Intel's microprocessor operations. The company's first product is the Genesil 400 System, which runs on a Digital Equipment Corp. VAX-11/750. A complete four-user system, including the VAX, has a price tag of $545,000, which may be a significant barrier to its adoption by large numbers of system designers. However, CAE observers expect that the Unix-based Genesil, or versions of it, will be available on stand-alone workstations and selling for less than $100,000 by the end of 1986.

Using Genesil is a three-stage process of design, verification, and tooling. For a typical circuit, the designer begins by making a first try at a block

GLEN R STEINER

Silicon Compilers, Inc., is the first to market, with a highly regarded silicon compiler system running on a Digital Equipment Corp. VAX computer. Sensing a potentially large and lucrative market, other start-ups—such as Seattle Silicon Technology and MetaLogic—are rushing to compete.

layout process and the routing of interconnections. The package is available on Mentor's Apollo-based series of workstations. In addition, Mentor recently reached an agreement with NCR Microelectronics (Ft. Collins, Colo.) to market NCR's CMOS (complementary metal oxide semiconductor) cell libraries on Mentor's workstations.

Although standard cell is one of the more promising design technologies—it can be highly automated, provides a good compromise between design times and performance, and costs less than gate arrays—it is not yet in wide use. Standard cell design systems are not as well developed as gate array design systems, but they are expected to catch up shortly. Some industry insiders feel that within the next 18 months standard cell prototyping times will fall to as little as 8–10 weeks, or to the point where gate arrays are today.

The next level of sophistication beyond the standard cell approach is the cell compiler, or macrocell design method, which provides a significant improvement in cost and performance over both the gate array and the standard cell. A macrocell design is assembled from large, optimized circuits—such as counters, random-access memories, and multiplexers—which are then placed and interconnected manually by the designer using a layout editor on a workstation. (In some newer systems, this process is performed automatically.) The optimized circuit block may be generated automatically from libraries of cell compilers or designed interactively with conventional layout tools. The design method is hierarchical—larger blocks may be built from smaller ones—so very large designs can be handled (in contrast to gate arrays) and the designer need interconnect only a few large blocks.

This approach has been followed by VLSI Technology, Inc. (VTI), a silicon foundry that offers a comprehensive set of CAE tools both for purchase by customers and for use at VTI's design centers. The company's cell compiler makes use of "megacells," large func-

Engineering workstation makers, such as Daisy Systems, are expanding their lines, particularly at the low end, to meet the expected needs of system engineers for designing application-specific integrated circuits.

diagram, completing a series of menu-like specification forms for the circuit elements of registers, multiplexers, buses, etc. These elements need not be designed from scratch—they are provided as a function set within Genesil. The system will flag errors in logic and timing as the specifications are entered, but the designer can also view a compiler-generated logic diagram to check the design himself.

When the designer is satisfied with the logic, the compiler generates three models: a functional description for simulating the design to make sure it will operate correctly, a timing model to check the design's performance for timing errors, and a layout model for placing circuit blocks and routing the connections. If the design performance is unsatisfactory, it's a relatively simple matter to revise the specifications or even use different functions. The models are then recompiled, and the design is simulated again.

Once the design is complete, the design engineer can generate the tooling tape for a particular silicon technology and a specific foundry for manufacturing the chip.

The current Genesil system is restricted to NMOS technology, but CMOS will be available shortly. Similarly, only a few foundries—notably American Microsystems, International Microelectronics Products, NCR Microelectronics, and VLSI Technology—have been certified by SCI.

While a silicon compiler radically shortens the time needed to design VLSI chips and particularly the time needed to consider alternative designs, the overall design and implementation of a chip can still be a relatively lengthy process. For example, the Digital Equiment Corp. MicroVAX datapath chip, designed with SCI's compiler, took a three-person team seven months to go from specification to silicon. The simulation and testing of the complex 37,000-transistor IC required considerable computer time, even on a computer as powerful as the VAX-11/750.

SST's cell compiler, called Concorde, offers much the same capabilities as Genesil but without the ability to automatically route the interconnections of modules. However, it is based on CMOS, a rapidly growing technology, and even has an analog cell option (unlike most of SST's competitors). Concorde has been integrated with Valid Logic Systems' SCALDstar workstation, a potentially powerful combination. And SST continues to add capabilities—for example, simulation—to its compiler, giving it more of the functions of a complete silicon compiler.

Yet SCI and SST will not have the silicon compilation field to themselves for long. Among the up-and-coming competition are at least a couple of custom foundries, notably LSI Logic and VLSI Technology. The latter has recently arranged to license a highly automated standard cell and gate array compiler from a British company, Lattice Logic.

A group of former Bell Laboratories researchers have started Silicon Design Laboratories (Basking Ridge, N.J.), which will shortly offer a silicon compiler for Unix-based workstations. According to vice-president Peter Rip, Silicon Design's compiler is based on a new language that supports both circuit attributes and computing. The compiler was developed for the Plex malleable computer project at Bell Laboratories.

A totally different tack is being taken by MetaLogic (Cambridge, Mass.) with the MetaSyn hardware synthesis language. MetaSyn, which grew out of the MacPitts IC design technology project at MIT's Lincoln Laboratory, allows the system designer to specify a design in terms of its behavior. It's claimed to be the only silicon compiler that can transform a behavioral description into a mask set for a full custom integrated circuit. MetaSyn is expected to be available within a few months.

How integrated circuits are designed

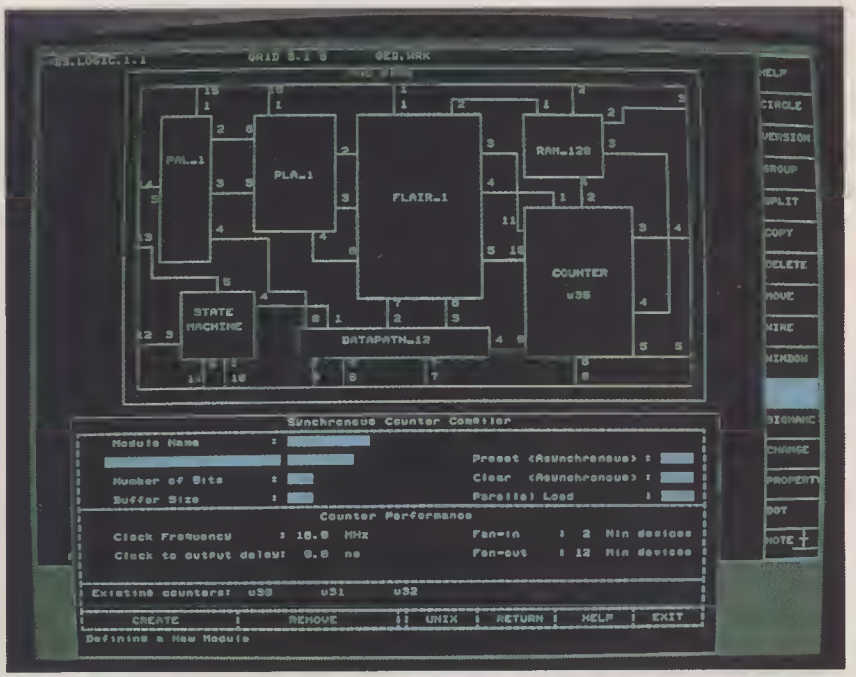
The design of an integrated circuit can be broken down into three major activities: the functional design of the circuit, the verification of the design, and the physical layout of the elements.

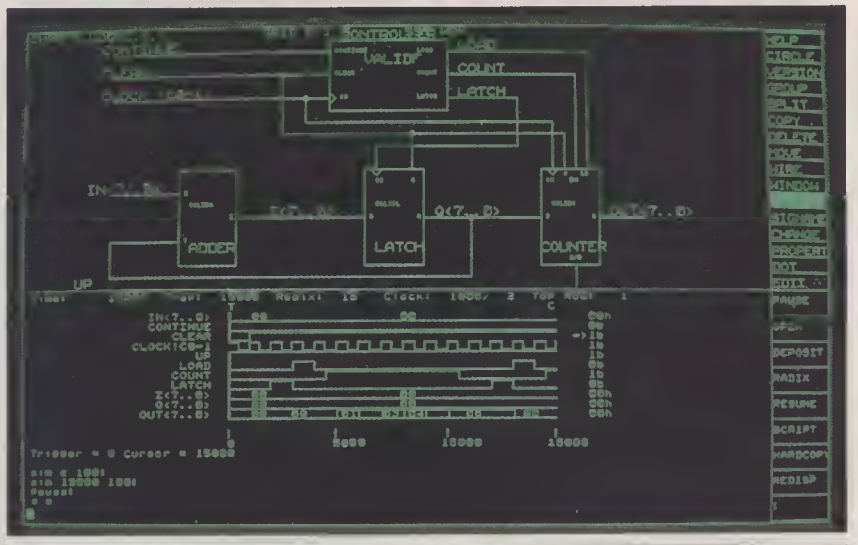
Seattle Silicon Technology's silicon compiler approach is based on this conventional design methodology. The process begins with the generation of a schematic diagram using a graphics editor (top photo), shown here on a Valid Logic SCALDstar workstation. The circuit elements are drawn and connected (upper half of screen) by the designer. Instead of selecting from a library of standard parts, the designer compiles modules for the specific application—in this case a synchronous counter—using an on-line menu (bottom half of screen). As decisions are made on the menus, the approximate performance of the module is immediately displayed on the screen (just below the specifications).

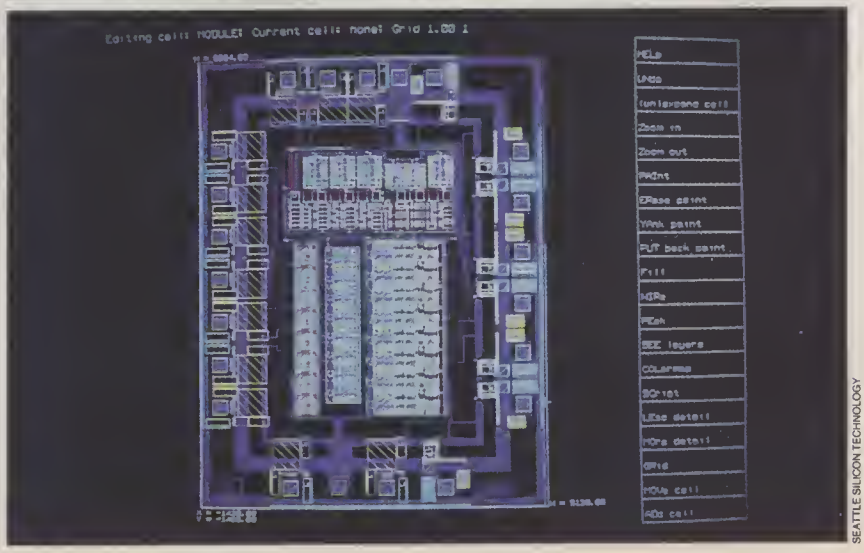
The next stage (middle photo) is the simulation of the design to verify that it is logically correct and has no timing problems. The display provides a window on the schematic (upper half of the screen) and the simulation waveforms in that part of the circuit (lower half of screen). The design will often be revised as the simulation results are analyzed; this may involve recompilation of several modules until the design performs satisfactorily.

When the user tells the compiler to construct a module, three representations are produced: symbols for schematic capture (diagram entry), a simulation model for design validation, and the actual module geometry for the final chip layout. When the engineer has verified the design, a layout is generated (bottom photo). At this point, depending on the type of circuit, the designer can finish the job either by laying out the modules manually and using a layout editor to make the interconnections or by employing the silicon compiler to do the placement and routing automatically.

Further simulation after layout is needed to verify that the design is ready for manufacturing. Current silicon compilers do not have this capability, so designers usually have to rely on simulation tools provided by the silicon foundry that will manufacture the circuit.







tional blocks that are designed for silicon area efficiency and that can be intermixed with user-compiled cells. VTI has generally been acknowledged as a leader in adopting CAE tools for ASIC design and in providing customer support, and other silicon foundries are now following its lead.

A cell compiler called Concorde is now available from Seattle Silicon Technology (Bellevue, Wash.), a company started by a group of designers from Boeing. The Concorde compiler has been adapted to Valid Logic Systems' SCALDstar VLSI design system for the creation of CMOS integrated circuits. Other cell compilers are expected to be available shortly from other companies—notably Lattice Logic (Edinburgh, Scotland), a spinoff from the IC design group at the University of Edinburgh, and Solomon Design Automation (Santa Clara, Cal.), a recent start-up headed by Jim Solomon, formerly manager of MOS analog R&D at National Semiconductor.

True silicon compilers, in which designers start with a high-level functional description of their system, are just beginning to appear as commercial products. The first is the Genesil System developed by Silicon Compilers, Inc. (SCI—San Jose, Cal.). SCI offers its own VAX-based design system, which supports four users, for a price of over $500,000. However, the company has recently received an infusion of capital from Daisy Systems, which is expected to offer a silicon compiler on its own single-user workstations for a price rumored to be around $200,000 and thus bring silicon compilation to a wider potential market.

SCI's silicon compiler requires that the user specify the chip's design structurally, as a set of components. This is a natural extension of a mode of design that is familiar to the conventional logic designer and the user of gate arrays and standard cells. An alternative design methodology is to specify the design in terms of its behavior, a potentially powerful technique. For example, MetaLogic (Cambridge, Mass.) is developing MetaSyn, a behavioral hardware-description language for design synthesis, simulation, and performance prediction. But although such a behavioral approach may eventually come closest to the way system designers will want to use computer-aided engineering for IC design—most of them do not now design or lay out chips, nor do they really want to—engineering-workstation makers are currently a long way from achieving this ideal.

MetaLogic is a spinoff from a small group of system designers at MIT's Lincoln Laboratories that developed the MacPitts silicon compiler on which the MetaSyn compiler is based. The principals—Frank Garofalo (president), Jeffrey Siskind (chief technical officer), and Jay Southard (director of technical marketing)—are all electrical engineers with strong programming backgrounds, not unlike their intended customers. Says Southard: "Our customers will be system designers with programming experience, which means anyone who has graduated or done significant design work in the last ten years."

Each of the "Big Three" workstation makers—Daisy, Mentor, and Valid—provides tools that are specific to its own products. But many believe that IC designers of the future will require a hierarchy of computing capabilities for complete design and layout. Robert Sumbs, executive vice-president of Valid Logic Systems, envisages a three-level set-up: personal computers (one per engineer) for entering schematic diagrams and for logic design; several powerful workstations for simulations, physical layout, and test generation; and a large mainframe computer that links all the units.

Such an arrangement seems inevitable, largely because of the spread of personal computers with increasing computational power and greater storage capabilities. In general, dedicated workstations can be used only for design activities, which are a relatively small part of the average design engineer's workload. A recent study by Hewlett-Packard estimated that design engineers typically spend only 30% of their time on design engineering (and only half of that time on actual design creation and modification) and the remainder on planning, management, and documentation—activities that can be greatly assisted by a personal computer. Thus the provision of inexpensive software for schematic capture (diagram entry), logic design, simulation, result analysis, and documentation could make better sense than the use of an expensive workstation.

Andrew Rappaport, president of the Technology Research Group (Boston), says that of the roughly 4500 single-user CAE workstations installed by the end of 1984, fewer than half were PC-based. By the end of this year, he says, that proportion should have grown substantially. Supermicro-based workstations from Valid and Mentor might be less expensive than their predecessors, but "when engineers buy PCs for design automation," says Rappaport, "they get a personal computer thrown in for free." Recognizing the trend toward personal computers, Daisy now offers an IBM PC-AT–based system, the Personal Logician, for around $25,000. While not exactly free, it performs at least as well as the original, and very successful, $75,000 supermicro-based Logician.

If the IBM PC is to be used for much more than schematic capture, high-resolution graphics and 32-bit processing are essential. Opus Systems, a Los Altos, Cal., start-up, will shortly introduce an IBM PC 32-bit processor board that will provide almost VAX-level computing power. Because such a processor will run a full System V UNIX operating system, the PC can be used with complex CAE progams.

Probably the best-selling PC-based design system is the Dash series offered by FutureNet (Canoga Park, Cal.) for the IBM PC, PC-XT, and PC-AT. The company claims to have sold over 2500 Dash systems. Not only does FutureNet cover schematic capture, but the com-

Plug-in special-purpose processors, such as this system developed by FutureNet, turn the IBM PC into an engineering workstation that can handle many aspects of integrated circuit design.

pany has recently begun to offer the Opus plug-in National Semiconductor 32032 coprocessor, which allows the PC to run the industry-standard CADAT logic and fault simulator produced by HHB Softron (Mahwah, N.J.). FutureNet offers the coprocessor with CADAT for approximately $25,000—about half the price of a supermicro workstation with similar capabilities.

Meanwhile, the workstation manufacturers are not standing idly by. Apollo has reduced its hardware prices to the point where Mentor Graphics can now offer an Apollo DN300–based schematic capture workstation that is comparable to Daisy's Personal Logician. The Logician-AT offers a simulation package, but Mentor counters with a diskless system that runs a remote simulator. And while higher-cost versions of the Personal Logician offer networking with Ethernet, the Apollo-based workstations use Apollo's own network, often reckoned the industry's best. Another plus: Apollo workstations can now run both the full Berkeley UNIX and AT&T's System V.

Workstation manufacturers are also extending the capabilities of their systems at the high-performance end. Valid Logic has attacked the problem of simulating complex VLSI devices in two ways—with a modeling system based on the use of actual devices and with a hardware-based simulation accelerator that runs hundreds of times faster than its software equivalent.

Almost any integrated circuit can be used as a model for this system—microprocessors, programmable logic arrays, floating-point processors, etc. The actual device is plugged into the Realchip system, and its inputs are stimulated to provide real outputs for the simulation. Thus the actual IC replaces a software model. Not only can Realchip be used with complex devices for which software models may be inadequate or unavailable, but it can also be used for simulating prototype devices or custom VLSI chips.

Not to be outdone, Mentor Graphics recently announced a similar method of incorporating actual devices into simulation models. The company claims that the new system, called the Hardware Modeling Library, can accommodate component clock speeds of up to 16 MHz, an important factor since current-

BUSINESS OUTLOOK

IC design tool market: changing as it grows

By simplifying integrated circuit design, the new methodologies of gate arrays, standard cells, and silicon compilation are expanding the number of professionals worldwide who can function, when the need arises, as IC designers. Consequently, the market for IC design tools, including software packages and workstations dedicated to running them, is also growing. The Technology Research Group (Boston) predicts that sales of automated tools for IC layout will rise from roughly $110 million in 1984 to $340 million in 1988, representing compound annual growth of 33%. And growth will continue to be strong into the 1990s.

But these figures don't tell the whole story; along with high growth comes fundamental change. Last year, nearly 80% of revenues from the IC design tool industry came from the sale of conventional geometric layout systems. These systems automate the drafting of chip layouts, but they require a one-to-one correspondence between what operators enter and see on the computer screens and what is ultimately etched into silicon. They are useful only to the few thousand engineers trained to design integrated circuits. By 1988, however, the Technology Research Group expects that conventional geometric layout systems will contribute only 15% of design tool industry revenues.

The real growth will be in design tools aimed at system designers—gate array and standard-cell placement and routing packages, silicon compilers, and symbolic layout editors. These systems automate the generation of geometric patterns and are therefore suited to system engineers not versed in the fine points of semiconductor physics and geometric chip layout. Sales of such advanced layout systems will grow 85% a year, from $25 million in 1984 to $290 million in 1988. Total installations will grow from 375 in 1984 to more than 6000 in 1988.

The biggest question now facing the design tool industry concerns who will sell these tools. Until recently, the industry was dominated by large computer-aided design (CAD) vendors—most notably General Electric's Calma subsidiary (Sunnyvale, Cal.), which was responsible for nearly two-thirds of all geometric layout systems in place in 1984. These older, minicomputer-based systems typically support three to four users and cost several hundred thousand dollars.

But as the emphasis in IC design tools shifts to automated layout software sold with new, microprocessor-based single-user workstations, old-line CAD vendors like Calma will face stiff competition. Daisy Systems (Mountain View, Cal.), Mentor Graphics (Beaverton, Ore.), and Valid Logic Systems (San Jose, Cal.)—the leading suppliers of computer-aided engineering systems—are enhancing their logic design systems with IC design tools. All three either offer or will shortly offer gate array and standard-cell layout systems and silicon compilers.

More important, these CAE vendors are now selling logic design workstations to the same system engineers who will seek layout systems as advanced IC design methodologies mature. Thus they have established an early toehold among the buyers who will ultimately contribute most to the expansion of the IC design market.

A raft of specialized start-ups is also addressing the market for advanced layout tools. Silicon Compilers, Inc. (San Jose, Cal.), and Seattle Silicon Technology were among the first in the silicon compilation market. Both companies are selling their software tools directly to end users but are hedging their bets through relationships with CAE vendors. Seattle Silicon sells its Concorde compiler through Valid Logic, while Silicon Compilers has sold a minority equity interest to Daisy Systems.

By year's end the market will be crowded with start-up vendors of silicon compilers and other advanced layout tools. Because system designers view IC design as only one small part of a much larger overall design task, the most successful vendors will likely be those that link up with mainstream CAE vendors or silicon foundries—suppliers of the custom chips themselves.

Indeed, next to users, silicon foundries have the greatest vested interest in IC design tools. As the design tool market grows to $340 million in 1988, the total market for semicustom chips will grow to $4 billion from $580 million in 1984. To CAE and CAD vendors, tools are an end product, but to foundries they are a means to a much larger market.

by Andrew S. Rappaport

ly available microprocessors have clock rates of 8 MHz or more.

The problem of simulation speeds is also addressed with Valid's Realfast simulation accelerator, an add-on unit with two processors that boost simulation speeds up to 500 times, according to Valid. One processor, termed an event engine, maintains simulation timing and schedules simulation events for evaluation. The other processor, the evaluation engine, resolves the logic states of the gates scheduled for changes by the event engine. With a simulation memory of up to 64 megabytes, Realfast can handle designs of up to 2.5 million gates, claims Thomas M. McWilliams, corporate vice-president of Valid.

Daisy's MegaLogician workstation also uses multiple processors to speed up the simulation process; Daisy offers a hardware simulator, called PMX (Physical Modeling Extension), that is comparable to Valid's Realchip. The savings in simulation time with these modeling workstations are dramatic. For example, the 1000-clock-cycle simulation of a 100,000-gate circuit might take 15 hours on a general-purpose mainframe computer. Such simulations are typically done overnight and the results analyzed later. But because the same simulation on a MegaLogician would, according to Daisy, take only three minutes, the design engineer could run simulations in a relatively interactive mode.

These advances, however, have not solved all the remaining problems in using CAE for VLSI design. The Technology Research Group's Rappaport still sees major problems in simulation, verification, and test, as well as in cooperation between workstation vendors and the silicon foundries that will be responsible for producing custom chips. "The principal factor separating winners from losers," he says, "will be how well vendors help system designers. Incomplete solutions to CAE support have nearly reached the end of their productive lives."

For example, Rappaport notes that simulation models on workstations often differ from those used by silicon foundries. Typically, the foundries use simulators developed for mainframe computers, such as HHB Softron's CADAT or GenRad's HILO, while vendors use their own proprietary simulators. Errors between the two types may be as simple as circuit timing, but this may be enough to cause inaccurate functional analyses. Chip designers are thus forced to run two sets of simulations—one on a workstation and another on the chip vendor's mainframe.

This is part of the general problem of standards that continues to bedevil CAE. System designers are unlikely to accept the technology unless they can be assured that the multiplicity of tools and databases can adequately communicate. CAE standards are "slow in coming and not widely adopted," says Bruce Gladstone, president of FutureNet. "We seem to have evolved into a spirit of noncooperation. And as long as everyone jealously guards their data, there is much less incentive for the customer to buy."

The only standard that is receiving much attention is the Electronic Design Interchange Format, which is adequate for transferring net lists and test patterns between systems. But CAE observers believe that it will not promote close integration between all CAE tools. For example, it does not remedy the lack of standards for simulation data.

In any case, the fast pace of development in CAE means that no viable standard would last very long; no workstation vendor would restrict system development merely to comply. However, the widespread adoption of PC-based workstations may produce some de facto standards, just as the IBM PC effectively made Microsoft's MS-DOS a standard operating system for personal computers.

From the design engineer's viewpoint, two key goals remain to be achieved before CAE can be widely accepted—integration of both software and hardware for the entire design and implementation process, and thorough training programs. Bob Graybill, an engineering fellow with the Westinghouse Defense and Electronics Center (Baltimore), echoes a familiar complaint: "There are too many workstation vendors and too many proprietary packages. For successful circuit design, we need the interactive capability of workstations but with access to shared databases and links to other users. Engineering is a team process."

The lack of adequate education and training is also a major stumbling block. A one- or two-week course is hardly enough to turn an engineer into a competent IC designer. All the workstation suppliers, some of the software tool developers, and several silicon foundries have thus been offering quite extensive training programs to fill the breach. Gerry Langeler, executive vice-president of Mentor Graphics, jokingly suggests that his firm is being transformed from a workstation company "with a small university attached" to "a large university with a small workstation company attached." Of course, if computer-aided engineering tools were genuinely easy to use, less support would be required and the tools would be accepted faster.

Langeler believes that as many as 30,000–50,000 engineers could be designing silicon chips by the end of 1986. While some might consider this an optimistic estimate from a vendor with a vested interest, the pressure for improvements in engineering productivity could in fact make the diffusion of CAE technology exceed even the wildest estimates. □

Jeffrey N. Bairstow is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES** *on page 74.*

Recognizing that the market for semicustom chips can expand only as fast as designers get effective tools, several foundries have aggressively pursued tool development. For example, VLSI Technology (San Jose, Cal.), a five-year-old vendor of custom chips, has pioneered work in cell compilation and symbolic chip assembly and sells design tools in addition to foundry services. Others, such as LSI Logic of Milpitas, Cal. (the leading CMOS gate array supplier), and Gould AMI Semiconductors of Santa Clara, Cal. (the most active U.S. custom chip foundry), fund large internal development groups to investigate and develop next-generation IC design tools. These tools not only help to ensure that foundries are well fed but also constitute a large part of the firms' competitive strategies.

And there's the rub for design tool vendors: When it comes to selling layout tools to system designers, foundries hold most of the cards. System designers used to purchasing only off-the-shelf components are concerned about their own ability to develop deliverable custom parts. Tool vendors can make bold claims about the quality and reliability of their software, but foundries are the ultimate sources of guarantees. Until system designers gain confidence in the layout process, they will prefer to purchase the tools recommended by foundries.

Andrew S. Rappaport is president of the Technology Research Group, a Boston-based market research and consulting company specializing in the computer-aided engineering and integrated circuit industries.

The uses

Summary:

Even the smoothest voice is discontinuous, especially in conversation. Data communications has bursts of message and periods of silence, too. Even TV has some "bursty" traits. GTE scientists are isolating silences and inserting other messages into them. This permits voice and data to coexist on the same channel at the same apparent time. The development stems from parallel research in microelectronics, silence detection, speech, voice compression and signal processing.

Without basic change, or vast growth, telephone networks will be unable to cope with the anticipated traffic of the 1990's. The proliferation of personal computers and data terminals has already placed a strain on switching and transmission facilities. It has also placed demands on networks that are much different from the original voice-communications concept, in which average time of connection was three minutes.

Today, far shorter and far longer connections abound, more subscriber lines are in demand, and there are growing needs for enhanced services and faster switching.

Out of research dating from 1979, GTE has developed a switching system that promises not only to triple present transmission capacity but also to process calls 20 times faster. The system is called Burst Switching.

The nature of speech.

Our world is full of holes. Matter is mostly empty space. Conversation is mostly silence. But, even though speech is 2/3 silence interspersed with bursts of sound from 0.1 to 1.5 seconds long, if that speech goes over a telephone line, the line is locked up for the duration.

But, with Burst Switching, we can shoehorn other messages into the silences, automatically easing the pressure on transmission facilities. Theoretically, in fact, we triple transmission capacity.

VHSIC.

Through Very High-Speed Integrated Circuits (in which we are currently researching devices with submicron feature size), we are able to make and break telephone connections at increasingly high speeds. Voice lines need be dedicated only for the very brief duration of voice bursts. At other times, channels are available for other voice messages, or for data streams which are also "bursty" in nature. In addition, video, because of its built-in redundancy, can be considered to have bursts, too.

# of silence.

Message compression.

The capacity needed to transmit speech can be made even smaller if the information that must be sent to make it recognizable can be minimized. Our scientists have reduced the 64 kb/s signals to 16 kb/s while retaining high quality.

Thus, transmission-capacity requirement is reduced by a factor of four.

We are working, as well, on techniques for compressing video signals from 90 Mb/s to 64 kb/s. This will have special relevance for such activities as video conferencing.

So transmission capability grows and switching becomes faster—and we can now envision future telephone systems able to carry billions of simultaneous calls.

The box at the right lists some of the pertinent papers GTE people have published on Burst Switching and related subjects. For any of these, you are invited to write GTE Marketing Services Center, Department TPIIB, 70 Empire Drive, West Seneca, NY 14224.

Burst Switching experimental model.

Pertinent Papers.

Burst Switching—An Introduction, IEEE Communications Magazine, November 1983.

New Switching Concept Integrates Voice and Data Bursts, PROFILE, September 1983.

A PCM Frame Switching Concept Leading to Burst Switching Network Architecture, IEEE Communications Magazine, September 1983.

Application of the Burst Switching Technology to the Defense Communications System, Proceedings 1983 IEEE Military Communications Conference, MILCOM '83, Washington, D.C.

Performance Evaluation of a Distributed Burst-Switched Communications System, Proceedings Second Annual Phoenix Conference on Computers and Communications, March 1983.

A Complementary Speech Detection Algorithm, Proceedings of GLOBECOM '83, November 1983.

GTE

In Burst Switching, the roughly 65% silence in speech can be filled with data streams and other messages, effectively tripling transmission capacity.

Aerodynamic design boosts fuel efficiency 25% in this experimental rig, says Fruehauf.

THE TRUCK OF

Electronically controlled rigs will slip through the wind, avoid collisions, stay under the speed limit, and shrink fuel costs

Motorists generally regard big trucks as smoke-belching beasts that guzzle fuel, break speed limits, and obstruct traffic. But radical changes are on the way. Trucks will eventually slough off their antiquated skins and emerge as streamlined, bullet-shaped darts. Truck makers are also turning to electronic sensors, microprocessors, and satellite communications to make the big rigs safer, more efficient, and easier to operate. Indeed, 21st-century truck drivers will function as supervisors who oversee a variety of computer-based systems.

Fueling the technological change is a hypercompetitive scramble within the $200 billion U.S. trucking industry. The battle for those shipping dollars has been especially intense since government regulation of interstate trucking virtually ended in 1980, resulting in cutthroat discounting and a proliferation of long-haul carriers.

Deregulation has led carriers to "realize that their survival depends on increased efficiency," says Dean P. Stanley, vice-president for truck engineering at International Harvester (Chicago), by far the leading U.S. seller of heavy-duty trucks. All new truck technologies ultimately aim at lowering operating cost, usually by reducing fuel consumption.

Wind cheating. At highway speeds, about half of a vehicle's fuel is burned to overcome air resistance. Traditional trucks are upright,

THE FUTURE

by Jeffrey Zygmont

bulky, and angular—fertile ground for streamlining. So far, aerodynamic improvements in heavy trucks have come in the form of add-on devices, particularly cab-top wind deflectors that ease airflow over the trailer.

Such add-ons are of limited value, however. For one thing, trucking companies use a variety of tractor/trailer combinations; if the two are incorrectly mated, a cab-mounted deflector can dump air into the gap between cab and trailer, ruining the smooth airflow the deflector is designed to promote. And deflectors work only with rectangular, van-type trailers; most other shapes, such as flatbeds, get no benefit.

One solution is to cover up the gap. "To be effective, gap seals have to be on the sides and also on the top," says Robert E. Hall, product development manager at Goodyear Tire and Rubber (Akron). Goodyear research points toward an inflatable bag that would route air over and around the joint between tractor and trailer yet retain the needed joint flexibility.

Several aerodynamic innovations have appeared on test vehicles. In the experimental FEV 2000, built in 1981 by Fruehauf (Detroit), a pneumatically actuated gap sealer extends automatically at speeds over 25 mph, covering the space between tractor and trailer to reduce drag by 16%. At 45 mph, aluminum side skirts lower to within five inches of the road to reduce turbulent airflow beneath the rig, cutting aerodynamic losses by another 18%. The trailer is tapered—the two sides curve inward, and the top slopes down—to create a high-pressure air pocket behind the moving vehicle. Square-bodied trailers leave behind a low-pressure cell, reducing aero efficiency as the truck is sucked backwards into its own wake (and giving a boost to tailgating motorists). All told, streamlining on the FEV 2000 reduces wind resistance by 57% for fuel savings of more than 25%, according to Fruehauf.

This experimental rig points toward the fuller integration of aerodynamics in truck design. But trucks won't look

radically different until manufacturers figure out how to eliminate the biggest aerodynamic problem: the radiator.

Conventional diesel engines must be cooled by passing a large volume of air through the truck's radiator. To maximize airflow, the front end of a heavy truck presents an upright wall, but this increases fuel consumption considerably. "If we're going to have a sharper nose on trucks, we're going to have to do something about cooling," asserts Tom E. Reimers, vice-president of International Harvester.

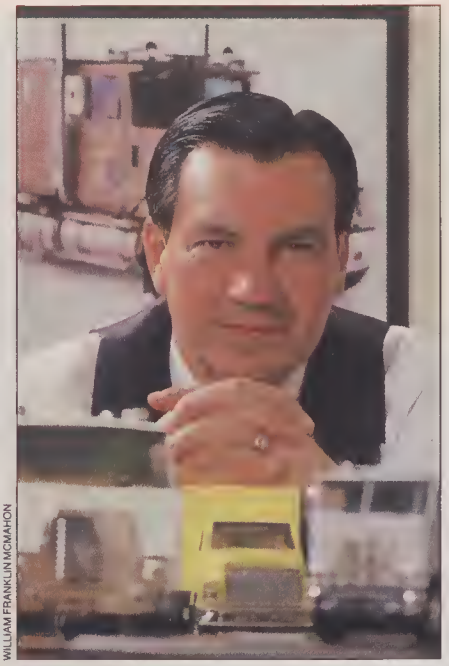
One approach, being pursued by several engine makers around the world, is to redesign the engine so that cooling is unnecessary. Lining the combustion chamber with ceramic insulation, for example, would significantly reduce the transfer of heat to metal engine parts. Such "adiabatic" engines remain in the experimental stage, however, mainly because ceramics are brittle and difficult to work with.

Smart engines. Stricter federal standards for emission of air pollutants from trucks are expected by 1988. Truck makers believe that electronic control of diesel engines should let them meet these tougher requirements without unacceptably lowering fuel economy.

The first step toward computerization of diesel engines has already been taken, with the electronic truck engine control (ETEC) from TRW's Transportation Electronics division (Farmington Hills, Mich.). ETEC was introduced in 1982 and is now used in about 9000 trucks. One trucking company reports that ETEC improved fleet economy from 5.9 mpg to 7.1 mpg, saving over $1 million a year in fuel costs.

ETEC works as a governor, preventing the truck from exceeding speed limits programmed by the truck owner. The mechanism for this control is a microprocessor-actuated valve that meters the flow of fuel to the injectors; if a sensor reports road speed above the programmed limit, the microprocessor commands the valve to close. In low gear or idling, ETEC will not let the engine race at more than 1500 revolutions per minute—even if the driver puts a brick on the accelerator pedal to keep the heating or air conditioning running smoothly during a roadside nap (a common fuel-wasting practice, according to TRW application engineer Paul Hetu).

More extensive electronic control will begin appearing this fall on selected 1986-model engines made by General Motors' Detroit Diesel Allison division (Romulus, Mich.). The Detroit Diesel Engine Control (DDEC) will be standard equipment on several of the company's 1987 engines. DDEC electronically directs high-current pulses to solenoids at each cylinder; the resulting movement of the solenoids injects the fuel. DDEC thus controls the two most critical parameters of diesel operation: the timing of the fuel injection and the quantity of fuel injected. Besides raising efficiency, the precise timing afforded by electronics eases cold-weather starts, cuts down on some emissions, and allows luxury features like cruise control. What's more, operating characteristics such as torque and horsepower can be altered simply by replacing a memory chip.



WILLIAM FRANKLIN MCMAHON

International Harvester VP Tom Reimers calls for standardization as truck makers turn increasingly to electronics.

Like the TRW system, DDEC achieves much of its gain in efficiency by wresting control from the driver. The system's electronic accelerator pedal supplies only one of several inputs to the microprocessor that sets engine speed. The chip also takes into account the readings from sensors detecting throttle position, crankshaft position, oil temperature and pressure, turbocharger air pressure, and outside air temperature. A preset maximum on the voltage available from the electronic pedal limits the speed the driver can get from the truck.

Another critical factor in fuel economy is gear selection. A computer-controlled transmission developed by Eaton (Cleveland) improves on the shifting performance of even the best drivers. Unlike a car's automatic transmission, which transfers power from engine to driveshaft via hydraulic fluid, the Eaton transmission uses the same mechanical gears as a standard manual system; the effect is the same as if a robot were pushing the clutch, letting up on the accelerator, and shoving the shift lever into place.

Sensors mounted on the transmission's input and output shafts monitor the speed of the shafts relative to each other and tell the system when to shift. What little influence the driver has on the operation comes via the electronic foot pedal. When the controller reduces the fuel supply at the start of each shift, it notes the position of the pedal; the system returns to the speed set by the driver when the shift is concluded. The appeal of such a system may lie more in its convenience than in its potential to save money; a prototype of the electronic transmission proved a modest 6% more fuel-efficient than a good driver shifting manually.

Eaton's transmission and Diesel Allison's engine controller are among the first of a coming wave of devices that could radically simplify the driver's job. "We shouldn't have people doing control system work that a small, inexpensive computer can do more effectively," asserts Trevor O. Jones, vice-president and general manager of TRW's Transportation Electronics division. "I would like to see the driver not be an integral part of any control system other than steering and, to a limited extent, braking."

But truck makers are approaching the electronic revolution with caution. They recognize that the electronic razzle-dazzle that might sell automobiles doesn't impress truck buyers, who have to turn profits with their rigs; each component must pay its way. Reliability is a big concern, too. "Some of the things we're putting on trucks are sophisticated and delicate instruments," says International Harvester VP Reimers. A truck engine is a brutal place; temperature under the hood can cycle between −40° and 250° F, vibration produces forces of 50 G's, and there's incessant pounding by sand, gravel, and stones.

Working together. Computerization of heavy trucks is also hampered by the structure of the industry. Unlike the passenger car business, where a handful of big companies dominate, the truck market is carved up among a large number of small manufacturers. This splintering presents two hurdles: The cost of new technology must be amortized over small production runs, and the great variety of manufacturers means that components designed for one truck may not work on another. "As we all get more and more into electronics, there will have to be some standards," says Reimers. "So far, there has not been a whole lot of discussion about them."

But a significant first step toward industrywide cooperation has just been taken. A joint committee of the Society of Automotive Engineers (SAE) and the American Trucking Associations (ATA) has published a recommended practice that will allow communication among diverse electronic devices.

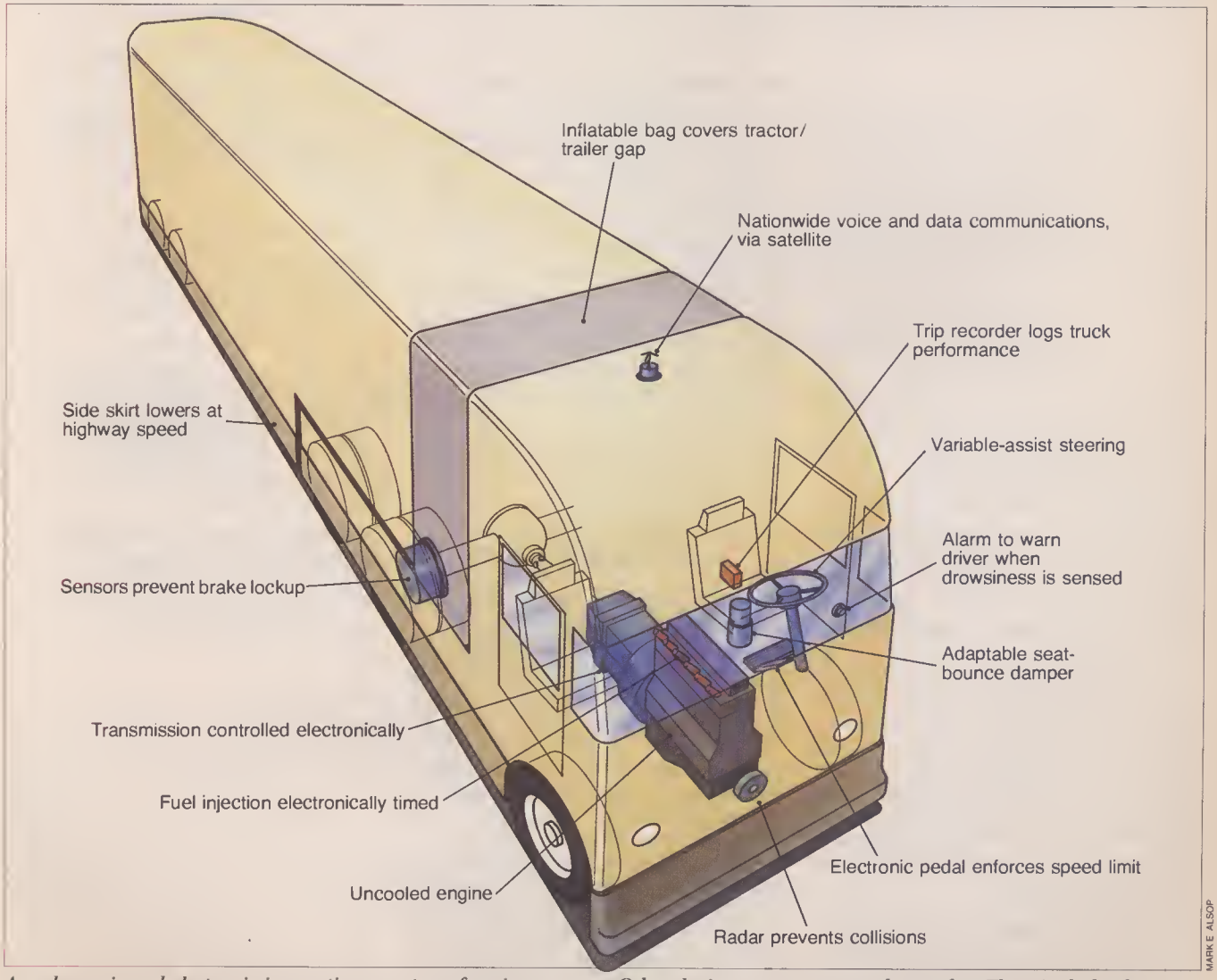
The SAE/ATA standard aims to prevent trucks from becoming overburdened with redundant sensors and wiring as electronic systems proliferate. For example, engine speed is monitored by an engine controller like ETEC or DDEC. But the same data also serve the dashboard display and the electronic transmission. Giving each device dependent on engine speed its own sensor would cause an assembly nightmare as well as difficulties in servicing.

If all electronic truck parts were made to common specifications, however, they could share data via a single wire running a circuit around the vehicle. Such a communications network—called a multiplexed serial link—would allow various systems to share data from the same sensors. The concept has received strong backing from TRW and is generally supported throughout the industry.

The SAE/ATA committee has already decided that the electrical interface for the truck data link will conform to the Electronic Industries Association's RS485 standard. Use of the standard allows a single serial link to handle up to 32 nodes, each consisting of a microprocessor-controlled sensor or control device manufactured to the RS485 specification. There will be no central "traffic cop" computer to direct the flow of signals; instead, each sensor will electronically detect when the line is available to transmit data. Just as important as the standard hardware is a common format for presenting information. The committee expects to propose such a communications protocol this summer.

Comfort and safety. The adoption of a standard truck communication link will also make it easier to address chronic human-factors problems like driver fatigue. A few possibilities are being considered:

- *Seat-bounce dampers.* The springiness of the driver's seat could be adjusted automatically according to electronically sensed road conditions. On smooth highways the seat would be firm, to minimize fatigue; on bumpy roads suspension should soften, to absorb jolts.
- *Climate control.* Heaters, air conditioners, and ventilation fans could be actuated electronically to maintain a far more uniform temperature inside the cab than is possible with conventional mechanical controls.
- *Variable power steering.* Drivers could get extra assistance at low speeds, when greater force is required to turn the wheels. Fuel would be conserved, too, by shutting off the assist mechanism (servomotors or pneumatic or hy-



Aerodynamic and electronic innovations are transforming heavy-duty trucks—improving safety, comfort, and efficiency. Some features shown, such as trip recorders, are already in wide use. Electronic engine control will soon be standard equipment. Other devices are not yet on the market. These include alertness sensors, uncooled engines (which, lacking a radiator, could vastly reduce wind drag), and antiskid brakes (though some new cars have them).

Electronics keeps on trucking

New electronic product opportunities for trucks will constitute a $100 million market in 1987, climbing to $200 million by 1992, predicts Ralph G. Colello, manager of Arthur D. Little's automotive unit (Cambridge, Mass.). Half the market will consist of engine management systems, he says, with the remainder composed of dashboard instrumentation, sensors and actuators, and power management and distribution systems. Trevor O. Jones, vice-president of TRW's Transportation Electronics Operations (Farmington, Mich.), expects that most functions currently performed by a driver will become automated by the 1990s.

A major factor in this developing market is federal legislation that mandates tougher emission standards by 1988. The use of electronic engine control to meet them will mark the formal beginning of the widespread use of advanced technology in heavy-duty trucks, says Colello. "Once you cross that bridge and electronics are on the vehicle, their use will begin to proliferate rapidly."

Truck manufacturers have an incentive to adopt the new technologies. The heavy-truck market is mature, and truck and component makers do not expect any dramatic industry growth. So manufacturers such as International Harvester (Chicago), Mack Trucks (Allentown, Pa.), Freightliner (Portland, Ore.), and Peterbilt (Newark, Cal.) could win new buyers by differentiating their products from competing models. And with top-of-the-line heavy-duty tractors going for as much as $75,000, there is room to add high technology options.

Truck manufacturers generally obtain electronic equipment from vendors that already serve the industry. Component firms that have shown an interest in electronics include diesel makers like Cummins Engine (Columbus, Ind.) and Caterpillar Tractor (Peoria, Ill.), transmission suppliers Eaton (Cleveland) and Dana (Toledo), and axle maker Rockwell International (Pittsburgh).

For example, Eaton is protecting its position as a leader in heavy-truck transmissions by developing sophisticated electronic gear control. Allied's Automotive Sector (Southfield, Mich.) is working with electronic controls to enhance the braking systems it already supplies to heavy-truck makers. Along the way it is acquiring expertise in electropneumatic controls that may lead it to some new product areas, reports Gary L. Casey, director of engineering for the automotive products development group. TRW has reorganized the most advanced portion of its truck components business as Transportation Electronics Operations, which manufactures the ETEC computerized engine control system, among other products.

However, electronic penetration of the truck market may not be rapid. These technologies are becoming available for heavy-duty trucks at a time when the industry itself is experiencing sharp competitive pressures. The last recession unfolded as motor carriers struggled through the early years of deregulation. Suddenly presented with an open market during an economic downturn, stronger motor carriers built on their competitive advantages to capture a greater share of shipping revenues. Meanwhile, weaker firms—more than 300 of them—went by the wayside. The American Trucking Associations (Alexandria, Va.) report that in 1983, when total motor freight revenues increased to $192 billion from recession levels, fewer than 7% of the motor carriers were "highly profitable." About 28% had only marginal earnings, and 29% were unprofitable. Thus only a few of the top firms have the capital to invest in new technology.

Payback becomes the key. Trucking companies want technologies that improve their competitive stance by lowering the cost of running a truck and by improving fleet management. "There are some awfully good things that can come with electronics," says Tom E. Reimers, a VP of International Harvester. "But there are also some things that would be nice to have but just won't have a payback." Carriers will therefore be looking with interest at claims such as those made by one fleet that purchased ETEC systems for $1200 each and reportedly gained annual fuel savings of $3500 per vehicle. "Wherever possible," says TRW's Jones, "truckers want to get the component to pay for itself in about a year."

—Jeffrey Zygmont

Reimers

Colello

"There are better ways to operate a truck than how we're doing it today. So we're stretching our minds to look at totally nontraditional methods in truck design."

Tom E. Reimers, VP Marketing and Product Development International Harvester

"Truck sales are going to be based not only on price but also on technological features. Competition is going to be more intense than in the past."

Ralph G. Colello, Manager Automotive Operations Arthur D. Little

DILIP CHAUHAN

draulic pumps) at highway speeds.

Other efforts aim at greater safety, especially through sophisticated braking systems. A new radar brake developed by Vehicle Radar Safety Systems (Detroit), for example, gives drivers advance warning of potential collisions. A transceiver no larger than a fog lamp emits a constant stream of microwave pulses and senses the echoes. A microprocessor calculates the closing rate between the truck and the obstruction or vehicle ahead, sounding an alarm when a crash is imminent—or even applying the brake automatically. Early trials of the radar brake so impressed Preston Trucking (Preston, Md.) that the motor carrier has ordered 551 of the devices and plans to install them (pending FCC approval) on all its long-haul trucks.

Antiskid systems can keep a vehicle under control during rapid stops (HIGH TECHNOLOGY, May 1985, p. 79). Sensors independently measure the rotational speed of all the truck's wheels; a single microprocessor computes each wheel's deceleration rate whenever the brakes are applied. The idea is that deceleration of each wheel should be proportional to that of the overall vehicle—which is the case as long as each tire has a firm grip on the pavement. But when a wet or icy patch breaks the friction bond, the wheel locks up and the truck skids.

Antiskid systems compare the sudden locking of the wheel with a reference deceleration rate and automatically open a valve to decrease air pressure at the locked wheel's brake. If the road surface is alternately dry and slick, the processor continually adjusts brake pressure to compensate for the changing friction condition.

For a brief period during the early '70s, the federal government mandated the use of antiskid brakes in trucks. But the mechanical technology used in those systems proved unreliable. The aftertaste of that failure lingers, and the trucking industry has shied away from the much improved electronic systems.

Another way to avert accidents is to monitor the driver's alertness. Some systems under consideration monitor the driver's blinking, perspiration, or even brain waves. Fruehauf's experimental truck took a more direct approach, keeping track of driving performance rather than bodily functions. In the system, developed by Fruehauf's Kelsey-Hayes division (Romulus, Mich.), sensors detect rotation of the steering wheel. In start-up mode, when the driver is presumably wide awake, a microprocessor notes how frequently the wheel is turned. Thereafter the system will sound an alarm if the frequency of turns changes significantly from that average, indicating possible drowsiness or "highway hypnosis."

"The driver should not be an integral part of any control system other than steering and, to a limited extent, braking," says TRW vice-president Trevor Jones (left), here examining a road-speed sensor mounted on a tractor.

Remote supervision. Technology will also aid trucking management. Particularly appealing to fleet operators—and distasteful to drivers—are electronic "trip recorders" that monitor a driver's road performance, including road speed and idle times. At the end of each trip, recorders can print out what amounts to a driver's report card, exposing any violations of company driving policies or highway speed limits.

Fleet owners marvel at the fuel savings realized by keeping drivers in line. One carrier reported that the payback for an earlier investment in roof-mounted wind deflectors did not come until the company also installed trip recorders. While the cab farings initially reduced fuel consumption, drivers negated that gain by racing faster to their destinations, thus arriving sooner but burning the same amount of fuel. Trip recorders forced the drivers to observe a company speed limit, reducing fuel use.

Even closer scrutiny of a driver's performance will be made possible by a planned satellite communication service. Sensors on the truck (such as an electronic speedometer) will send their readings to an on-board microwave transmitter, which can then relay the signal to the fleet terminal via satellite. The service should begin in 1988, according to the developer, Mobile Satellite (King of Prussia, Pa.).

Such a hookup could also provide a continuous log of the truck's location to within a quarter of a mile. What's more, the fleet manager could remotely control certain truck functions, such as the operation of the refrigeration unit when perishables are being shipped. The system could handle voice transmission as well, permitting truckers to talk to each other and to their companies from anywhere in the country. The celebrated CB radio, which cannot reach past the horizon, may become obsolete.

These first attempts at modernizing the heavy-duty truck could lead to a complete revamping of land transport vehicles. "Once you've bought the electronic sensors and controllers, you're halfway there—it's easy to add on more features as you go," says Gary L. Casey, director of engineering at Allied's automotive product development group (Southfield, Mich.). For example, pressure sensors mounted in the wheels could trigger warning lights on the dash when tires needed inflation. And the same components used for skid control could easily be adapted to automatically apply sequential braking, rear axle to front. Under many circumstances this technique would prevent the trailer from skidding out ahead of the tractor—the notorious jackknife. Someday, after these systems have become standard equipment, the motoring public may breathe a little easier. □

Jeffrey Zygmont, of Wyandotte, Mich., is a former mechanic who has written extensively on the automotive industry.

For further information see **RESOURCES** *on page 74.*

Where engine

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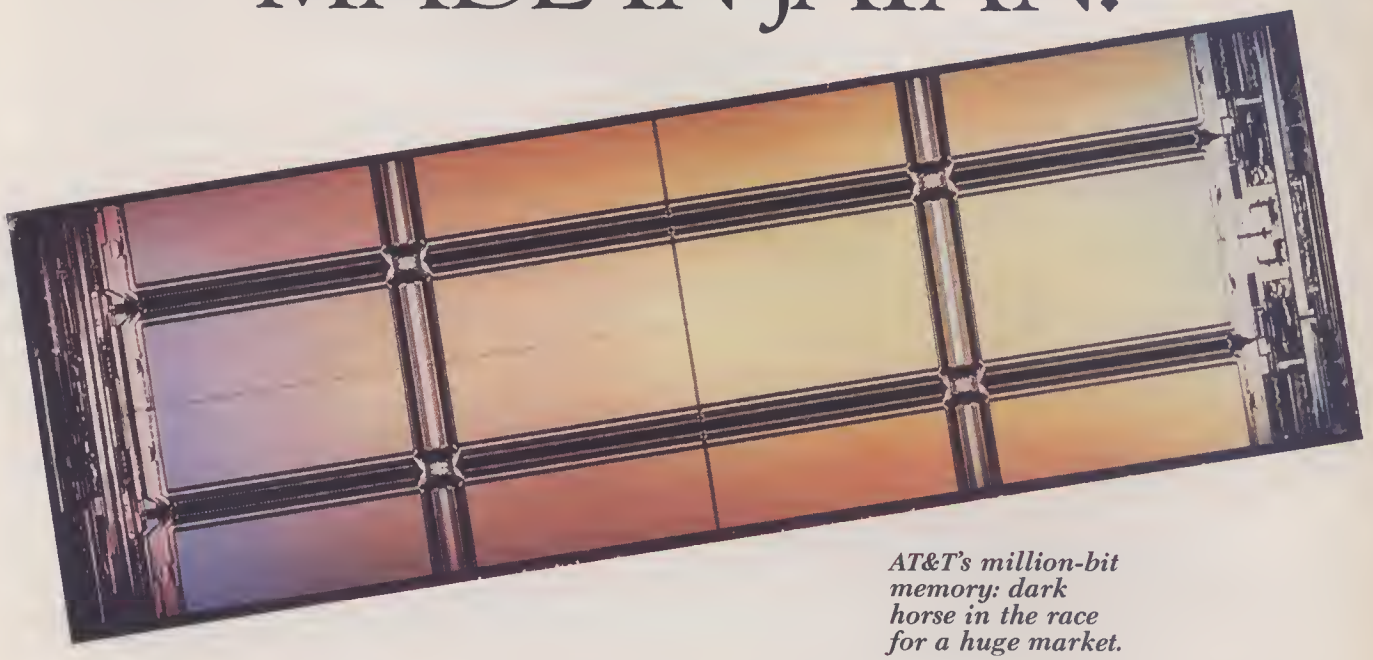
THE MEGABIT RAM: MADE IN JAPAN?



AT&T's million-bit memory: dark horse in the race for a huge market.

Integrated circuit manufacturers are on the verge of producing one of their dream chips: the 1-million-bit semiconductor memory. Some prototypes are ready now, and volume production may begin as early as next year. But if current memory chip sales and technical conference papers are any indication, Japanese producers will virtually own the market for this device, called the megabit DRAM ("dee-ram," which stands for dynamic random-access memory).

The stakes are high, but the economics are brutal. The multibillion-dollar RAM market comprises parts that, in many cases, sell for less than $2 each. RAMs may cost over $100 at introduction time, but in a couple of years the price plummets to below $5 a chip and continues to fall. Such will likely be the fate of the megabit RAM, even though this ultrahigh-tech device will be much more costly to manufacture than its forebears. Consequently, U.S. integrated circuit makers may find it extremely difficult to compete.

Lane Mason, a senior industry analyst for Dataquest (San Jose, Cal.), a semiconductor market research firm, thinks that the U.S. "has had it" in the DRAM business. As long ago as late '82/early '83, 256K-bit RAMs began to emerge from U.S. manufacturers. But volume production is just beginning, and the Japanese now control about 92% of the world 256K market, as well as nearly 70% of the total DRAM market, now pegged at about $5 billion. And though Texas Instruments says it is now shipping parts in volume, they are being made at its plant in Japan.

The megabit RAM boasts the highest storage capacity yet achieved, but the world's thirst for memory bits seems insatiable. Dataquest predicts that sometime in the early '90s the world market for dynamic RAMs will reach about $15 billion, some two-thirds of it for megabit parts.

Economic factors favor the Japanese winning the world's biggest semiconductor market ◆ by John G. Posa

And the stakes will get much higher. Around 1995 the DRAM market should top $30 billion, with 4-megabit chips accounting for half the business. By the turn of the century, the market for RAMs could hit a staggering $60 billion.

The reason for the huge growth of the RAM business is that anything computerized or based on digital electronics needs increasing amounts of memory to function competitively. More memory usually means a more powerful machine. Many of today's personal computers hold 128K bytes of RAM chips on their printed circuit boards (there are eight bits in a byte, which can represent an alphanumeric character or symbol). As 256K-bit chips get cheaper, many users will upgrade to 512K-byte, or half-megabyte, machines. By 2000, personal computers will have a gigabyte (8 billion bits) of main memory, and they will be affordable by almost anyone.

Larger computers, of course, need even more memory. Minicomputers come with several megabytes; mainframes, up to a gigabyte. And as computers of all kinds are made more "user friendly" through speech synthesis, voice recognition, and image analysis,

What makes a RAM tick

The million-bit memory is called a megabit dynamic random-access memory, or DRAM ("dee-ram"). It is dynamic in that the storage cells will not retain their data without being "refreshed" with electrical pulses supplied during idle periods. (Static RAMs, which need no refreshing, require cells that are larger and more complicated, leading to far less dense, more costly devices.) The memory is called random-access because it takes the same amount of time to read or write any cell on the chip (unlike serial memories, which store data in long strings).

Megabit RAM chips measure about 4.8 × 14 millimeters, or about ⅛ × ½ inch. The chip is cemented into an 18-pin package that is ⅗ inch wide and about an inch long. The external pins connect to bonding tabs in the cavity where the chip is placed, and a bonding machine affixes wires from pads on the chip to the bonding areas in the package. With expensive ceramic packages, a metal lid is soldered onto the cavity. With cheap plastic packaging, the chip, bonding wires, and pin assembly are encapsulated using a molding machine.

The megabit RAM stores 1,048,576 (2^{20}) bits of data. In other words, 20 bits—each either a *1* or a *0*—can be combined in 1,048,576 different ways. To "address" a distinct location in the megabit RAM requires 20 address bits. But because providing all 20 lines would result in larger, more expensive packages, the address is broken up into two 10-bit chunks.

The first 10 bits are called the row address; the second 10 bits, the column address. Each 10-bit address can represent 1024 (2^{10}) possible combinations. When they are brought into the chip, they are "decoded." The unique codes on the 10 address lines, any of which can be a *1* or a *0* at a given time, are electrically expanded to select a single line from a full 1024 lines.

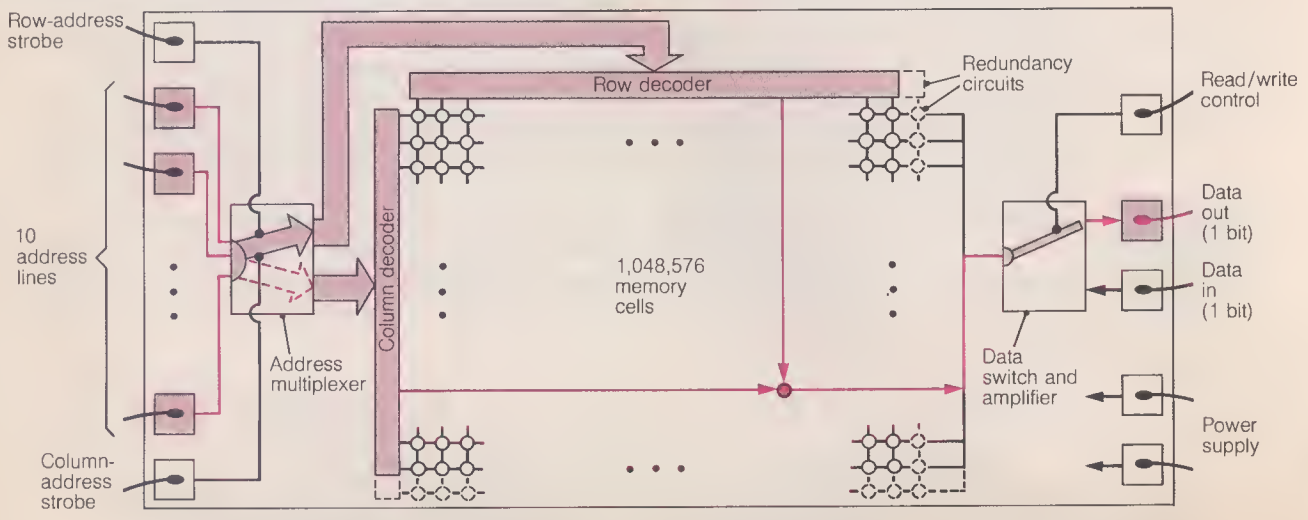
The two 10-bit addresses are separately decoded by the chip, resulting in 1024 signal lines apiece. The two sets of lines are arranged perpendicular to each other on the chip, resulting in 1024 times 1024 locations, which are the 1,048,576 cells.

To read a bit of memory, the chip is presented with the first 10 address bits, and a row-address strobe pin is toggled to remember this value. Then the next 10 bits are brought in over the same address lines using a column-address strobe. The combination of the two 10-bit addresses identifies one out of the million cells.

When a cell is pinpointed, a path is created from it to a data switch controlled by a read/write pin. In the read mode, the data from the specified cell are amplified and sent to a data-out pin. Everything is the same for a write operation, except that the data switch couples a data-in pin to the selected memory cell, allowing it to store the external data.

Of course, this is a rudimentary view of the simplest possible DRAM configuration. Practical designs contain supplemental circuitry to increase performance, reduce power consumption, or enhance reliability. For example, instead of just one bit, some DRAMs allow the user to read or write four or eight bits at a time. This means a corresponding increase in the number of data input and output pins, and a larger, less popular package.

Many megabit chips also offer redundancy—spare cells and decoders in case primary circuits are rendered inoperative by a defect of some kind. If testing by the manufacturer reveals a small number of bad bits in a chip, they can be permanently replaced with the spares. A precisely controlled laser beam seems to be the preferred surgical method for performing the substitutions.



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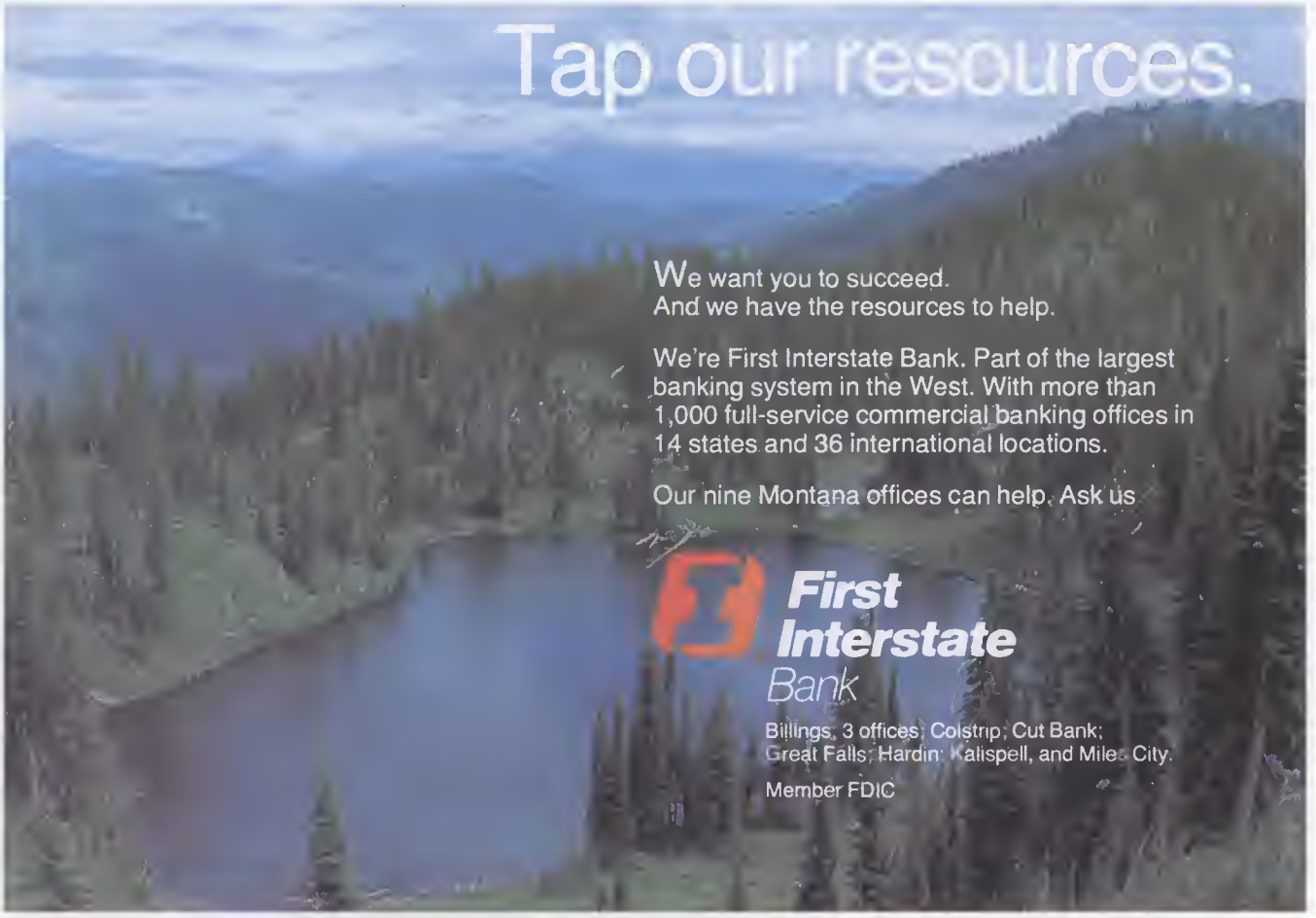

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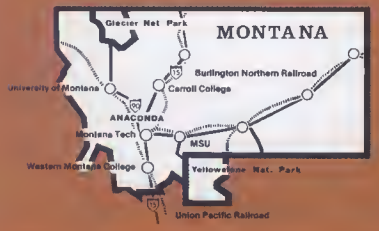

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RAM requirements will explode.

Shojiro Asai, manager of Hitachi's VLSI Department, uses a figure of merit called "DRAM possession per capita." Now, he says, there is less than one 64K chip for each person on earth; but by the end of the century he expects that there will be 100 64-megabit chips per capita!

With this tremendous market potential, why isn't there stronger competition for the growing Japanese leadership? The answer is complex.

Manufacturing skill is the key to the market, and a look at the economics of making the devices shows why. The 64K (2^{16}- or 65,536-bit) RAM, for example, now sells for about $1.50. Given the current dimensions of the chips, a manufacturer can expect to put about 500 chips on a disk-shaped wafer. But not all of them will be good.

Depending on the age of the processing equipment, it might cost around $250 to process each wafer. To break even at $1.50 a chip, a third of the chips on the wafer have to work perfectly. To attain an acceptable profit margin, two-thirds of the chips have to be perfect. Achieving this 66% yield is difficult but not impossible. Yet any added expenses for final assembly, testing, or shipping—or for factory hazards—can eat up profits.

The situation will be worse for the megabit RAM, especially in the early stages. The chips will be much larger, two to three times the size of 64K chips. Even if state-of-the-art six-inch wafers are used, only 350 chips will fit on a wafer. And even if "shrinking" the chip pushes this number back up to 500, wafers will no longer cost only $250. Six-inch wafers, along with all the new equipment required for 1-megabit complexity, could bring the processing cost to $1000 or more. By the time a firm planning to enter the market is able to achieve such density, prices are likely to have dropped, and the window of profitability could well be missed.

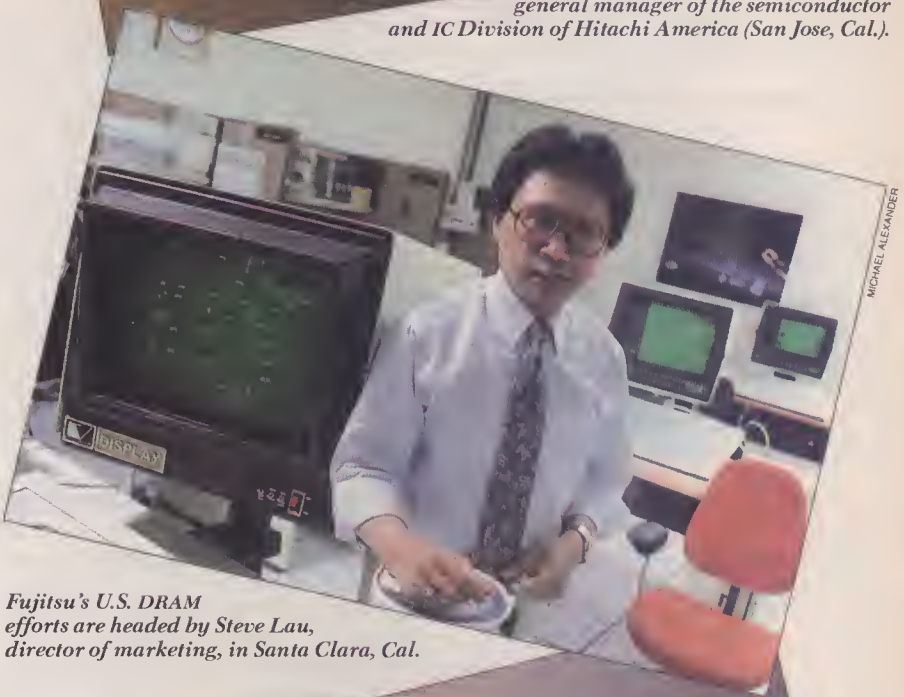
For many reasons, such price tags are easier for the Japanese to handle. All Japanese semiconductor companies are parts of much larger corporations that build computers or digital systems. This equipment requires huge numbers of RAMs. The heavy internal demand for high-density memories encourages early development and helps the vendors weather painful pricing periods while gaining manufacturing skill.

The Japanese government also supports the industry. This support includes low-interest loan guarantees and national technology programs aimed at long-term objectives. Unlike bottom-line-oriented U.S. producers, Japanese

The three leaders

K. GYPSY ZABOROSKIE

Tadao Koga is deputy general manager of the semiconductor and IC Division of Hitachi America (San Jose, Cal.).



MICHAEL ALEXANDER

Fujitsu's U.S. DRAM efforts are headed by Steve Lau, director of marketing, in Santa Clara, Cal.

DOUGLAS SCHWARTZ/NEC

John Marck (right), director of memory marketing for NEC in the U.S. (Mountain View, Cal.), plans sales strategy with Dan Domingo, DRAM product marketing manager.

chip makers will gladly break even—even lose money—to gain market share.

The Japanese workforce is also more stable, particularly in contrast to the job-hopping environment of Silicon Valley. And semiconductor memory production, more than many other technologies spawned by U.S. entrepreneurship, is particularly well matched to Japan's manufacturing mindset; management and discipline are the key to the zero-defects approach needed to achieve any return on investment.

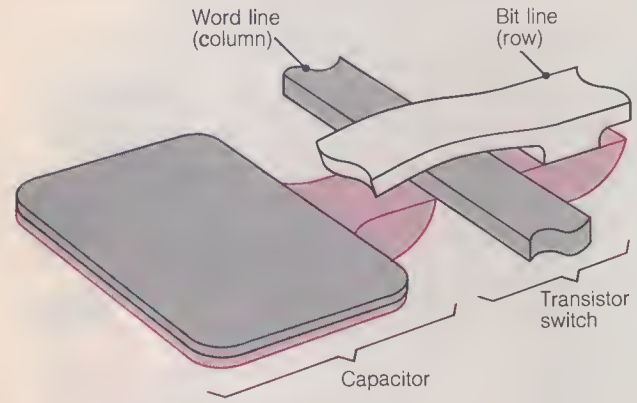
Still, the memory market is one of only a few areas in which U.S. semiconductor firms are losing their supremacy. Memory chips now achieve profitability through manufacturing technology rather than through clever, innovative circuit design. By contrast, application-specific chips—even microprocessors—are much more difficult for the Japanese to develop for the U.S. market. It is important for vendors and system designers to interact extensively to define the functional requirements for a design—a difficult task when the vendor is far away.

New memories are much easier to define, since basic functions remain fairly constant for each new generation. There are even U.S. committees that spell out exactly how next-generation memories will have to be packaged in order to be compatible with standard equipment designs. For every new generation, storage density must be quadrupled, but this can be done through miniaturization based on cleaner work areas (so that minuscule particles do not foul up circuitry of such small dimensions) and by investing in more advanced processing equipment. Japan's huge industrial conglomerates readily incur such capital expenditures.

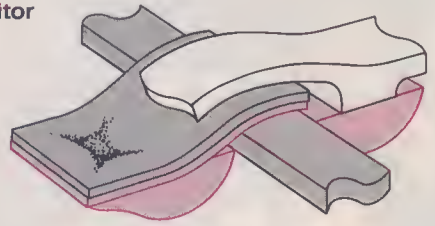
Inside the million-bit RAM

Dynamic RAMs once used three transistors and a capacitor (for charge storage) at each cell location to hold data. A decade ago IBM found a way to get by with a single transistor and capacitor. Now all DRAMs, including the megabit designs, use this arrangement. The transistor acts as a switch to transfer charge to and from the capacitor, which is a sandwich of conducting and insulating films that stores electrons.

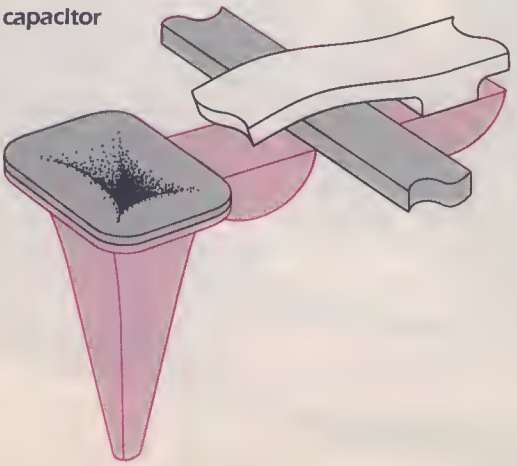
(A) Standard 64K and 256K DRAM cell structure



(B) Stacked capacitor



(C) Trench capacitor



In current 64K and 256K DRAM designs, a cell is selected by simultaneously activating one row and one column in the memory's storage array (**A**). When this occurs, the column (or word line) allows current to flow from the row (or bit line) to the capacitor.

To write into the cell, data presented to one of the chip's external pins charge (or discharge) the current state of the cell to store a *1* or a *0*. To read, a cell is selected and the status of the capacitor creates a signal that is amplified and fed out to a different external pin.

Having reduced the number of transistors from three to one, designers are now focusing on reducing the size of the capacitor for the megabit RAM. This will be effective but tricky, because the charge retention capability of the capacitor is related to its surface area. Below a certain size, external electrical disturbances may cause reliability problems called soft errors.

The films that make up 64K and 256K DRAM capacitors are simply deposited on the silicon chip, next to the transistor switch. For the megabit RAM, designers are trying to find a way to keep the capacitor's surface area constant while reducing cell area. One approach is to use different films for the capacitor so that it can retain charge more effectively. Some companies are trying this, but the amount of cell reduction does not seem worth the trouble of learning how to work with new materials.

Another approach is to flip the capacitor on top of the transistor switch (**B**). This has been tried by Japan's Hitachi and Nippon Telegraph & Telephone with varying degrees of success; proper stacking is difficult to achieve.

The winner for the megabit RAM will probably be the trench approach (**C**). There are different trench designs, some requiring one per cell, others requiring one for every two cells. But the basic idea is to use a special etching technique to put a million tiny hollow spikes into the surface of the chip and then deposit the capacitor films into them. Texas Instruments and several Japanese companies are going this route.

Techniques like trench capacitors will work for the 4-megabit RAM and probably even for the 16-megabit chip. But then what? Ironically, a second transistor will probably have to be added to amplify electrical signals right at the cell level. Chip features will be so minute that without extra amplification the circuits could not operate reliably in the presence of external noise. Some of these "gain cells" have already been proposed, with one transistor placed on top of the other.

In the early days of DRAMs, clever circuit designs meant as much as processing skill. In the 1K-bit dynamic RAM of the late '60s, each memory cell required three transistors and a capacitor, or charge storage element, to retain data (see "What makes a RAM tick," p. 38). Then IBM discovered a way to do the same job with just one transistor (and capacitor) per bit. This revolutionary new design concept led to 4K chips by the early '70s. Later in the decade, Mostek (Carrollton, Tex.) introduced a 16K chip with so many circuit design innovations that other manufacturers eventually had to adopt some of them to stay in the race.

Since the 16K RAM, however, the name of the game has been scaling down—making things smaller and smaller—to cram more bits onto each chip. Today's 256K chips incorporate physical geometries of 2 microns, and 1-megabit chips need 1-micron features. (The diameter of a human hair is about 75 microns.)

To produce 1-megabit chips, the manufacturer may have to spend a hundred million dollars on enormous, ultrasterile factories loaded with equipment capable of patterning 1-micron features. Not only are the memory cell structures in megabit DRAMs exacting, but special new vertical processing techniques must be used to conserve silicon "real estate" if the chips are to fit into slim standard packages.

Dataquest's Mason explains that U.S. producers, fearful of the Japanese, either tripped up on their most competitive, mainstream parts or "headed for the corner" by developing specialized, less price-sensitive DRAMs with much smaller markets.

Mostek, for instance, introduced a higher-performance 256K DRAM with a 32K × 8-bit organization in a larger package; the market for this chip is likely to be orders of magnitude smaller than for mainstream DRAMs. And Micron Technology (Boise, Id.), a leader at the 64K level, recently brought out a large, controversial 256K chip that can automatically correct for reliability problems called soft errors, which are caused by external electrical disturbances (triggered by high-energy particles in the atmosphere, or sometimes by spontaneous emission of particles from materials used for packaging the chips). But because of the current industry downturn, the firm had to lay off half its workforce earlier this year.

Intel (Santa Clara, Cal.), which abandoned DRAMs during the 16K era, is now trying to get back into the market with a 256K chip built via a more expensive process called CMOS (complementary metal oxide semiconductor) that results in much lower operating power. Intel's part works, but profitability appears dubious given the high production costs and questionable market for the chip. Intel, too, recently cut back its workforces in Silicon Valley and Portland, Ore. Says Gordon Moore, the company's chairman, "Commodity memories are not a business for faint hearts or shallow pockets."

Two of the most successful U.S. 64K RAM manufacturers—Motorola (Austin) and Texas Instruments (Dallas)—have been sampling 256K parts while Japanese vendors have been producing at rates of millions a month. Other hopefuls—Inmos (Colorado Springs) and Advanced Micro Devices (Sunnyvale, Cal.)—have designed 256K parts, but neither company has been a major force in past generations of DRAM production.

The situation in Japan, says Dataquest's Mason, has been quite different. The top three producers—Hitachi (Tokyo), Fujitsu (Kawasaki), and Nippon Electric Co. (Kanagawa)—all got off to a solid start with mainstream 256K RAMs. Even second-tier producers—Mitsubishi (Itami), Toshiba (Kawasaki), and Oki (Tokyo)—have made decent showings with mainstream designs.

DRAM leadership has changed hands at each generation and will continue to go to the companies with the greatest technical and financial commitment to the business. But "at each generation," says Dick Foss, president of Mosaid, a memory design consulting firm in Ottawa, Ont., "Americans say, 'just wait till next time.' And quite frankly, each time they get further behind." Once the leader was Intel; then it was Mostek, then Motorola and Texas Instruments. Now Hitachi, NEC, and Fujitsu are in the catbird seat. But are they there to stay?

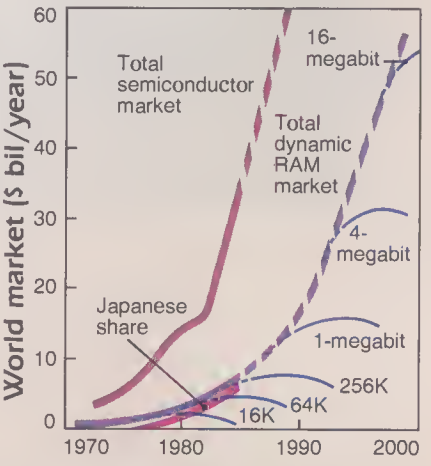
The Japanese certainly appear poised to dominate the market for megabits. Indeed, there are rumors that at least two Japanese producers have already given sample 1-megabit parts to major U.S. minicomputer manufacturers. "But they probably won't introduce the parts until it's commercially toothsome," says Mosaid's Foss. And Mitsubishi is already designing photomasks for a 4-megabit DRAM with 0.5- to 0.7-micron lines, using molybdenum silicide to improve adhesion over conventional chromium masks.

Since the Japanese companies are vertically integrated in very large corporations, they have the resources and the built-in internal demand from their end-equipment businesses to justify large expenditures for development and production of advanced memories. But a similar situation might eventually propel the U.S. back into the DRAM market battle. Bell Laboratories, which once designed chips for use only by AT&T, has begun to develop parts for the commercial market. Its Allentown, Pa., operation recently unveiled a megabit DRAM that is truly a mainstream component. It offers high performance and low power, and it fits into a small, standard package. With initial manufacture slated for late this year, AT&T says full production of the chip is set for early 1986.

AT&T already controls some 5% of the market for 256K RAMs. If it really wants a big chunk of the megabit DRAM market, it could conceivably muster the resources to give the Japanese a run for their money.

IBM also produces a vast volume of integrated circuit chips; but so far, they have been only for internal consumption. Its General Technology Division (Essex Junction, Vt.) recently described "an experimental 1-megabit DRAM," but like most IBM chips, it involves a nonstandard assembly and packaging scheme that would present problems for the merchant market. So even though IBM will probably continue to be a leader in DRAM designs, commercial production of the devices is unlikely.

But even if American companies are too late for the megabit chip, the larger, more lucrative markets that follow are still unspoken for. History has shown that one advanced design can turn the tables, enabling the innovator to "leapfrog" past the stunned competition. Such a leap will be necessary for U.S. RAM producers to get back in the race. □



Japanese manufacturers command about 92% of the 256K market—and about 70% of the total DRAM business, already over $5 billion a year and climbing rapidly.

S. ASAI, HITACHI, DATAQUEST

John G. Posa, a freelance writer, is sales manager of Crystal Specialties (Portland, Ore.), which makes gallium arsenide processing equipment.

For further information see **RESOURCES** *on page 74.*

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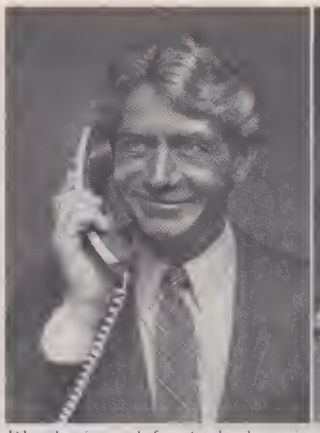

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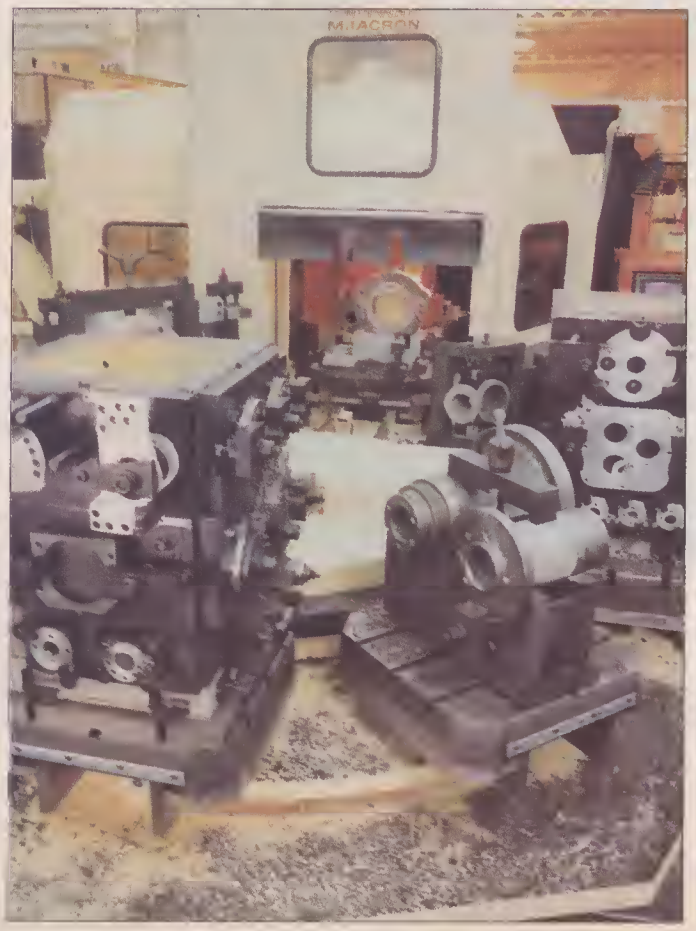


by Ernest Raia

Untended machining could step up productivity on the factory floor

HELPING MACHINE TOOLS HELP THEMSELVES

Automated manufacturing has become something of a buzzword in the quest for higher productivity. Computers and data links have been invading factory floors. But when it comes to machine tool technology, the overall picture is dismal.

Theoretically, most machine tools could run around the clock, seven days a week, for a maximum production time of 8760 hours a year. But in the real world, only about 6% of the available time is actually spent in production. "That means we're paying for this capital equipment with one hour's work out of 17," complains Roger Seifried, manager of manufacturing R&D at Cincinnati Milacron, the nation's leading machine tool builder. One reason is that approximately 75% of all machined parts are produced in batches—lots of 50 or less—in which capital equipment utilization rates are abysmal.

The new generation of flexible manufacturing systems will have to do much better to justify their high capital costs. One promising concept now on the drawing boards is machining centers that will run untended for long periods of time, even while producing dissimilar parts. Such units—operating either as stand-alone tools or as part of a larger flexible machining system—will employ a range of sensors and feedback devices for protecting costly equipment, detecting worn or broken tooling, and maintaining tight quality control.

For now, however, no firm in the U.S. is running its machine tools completely untended, according to Richard Kegg, Cincinnati Milacron's director of machine tool research. Milacron is now testing a machining center that runs untended during a second shift while producing parts for robots made at its Cincinnati plant.

The reason for caution in switching to true untended machining is the fear of wrecking a half-million-dollar machine in case of trouble with no one around to shut it down. Keeping machine operators available for three shifts is a costly proposition. But are such automated machines affordable if they *aren't* kept running around the clock?

Before manufacturers can confidently run automated machine tools with no operator present, better diagnostic and sensing systems are needed. "The more one attempts to perform untended machining, the more one appreciates the initiatives of the human operator," says Kegg. Machine designers quickly get bogged down in a myriad of little challenges that are routinely handled by human operators—clearing away shavings, for example, and preventing stringers (long, continuous shavings) from wrapping around the part or tooling.

But none of these problems is insoluble. Shavings can be cleared away with an occasional blast of air or by operating the spindle in reverse—simple features that can be easily provided for by the machine software. "Indeed," says Kegg, "the importance of intelligence [software and sensors] is eclipsing the importance of iron [standard machine tool hardware] in untended machining centers." Tool malfunctions are of special concern in untended machining. An experienced machinist is alert to any number of signs that the cutting tool is nearing the end of its life—sparks, unusual grinding noises, poor surface finish, and so on.

Now, sophisticated new sensing systems, capable of detecting and automatically replacing broken or worn components, are gradually being substituted for the eyes and ears of the machinist. Devices now on the market or under development measure phenomena such as force, vibration, and sound. Because they operate while a part is being machined, they are thus termed "in-cut" systems. If a tool breaks, the sensor must relay the information to the system immediately—preferably within one revolution of the workpiece—in order to avoid serious damage. For a workpiece rotating at 1000 rpm, the sensing system must therefore respond in under 60 milliseconds. Ordinary tool wear, however, is a gradual phenomenon, so corrective action need not be so immediate.

A difficult problem in monitoring machine operation is that sometimes the tool tip is obscured. The sensing system must therefore rely on indirect measurements. "Optical techniques are impossible," says Franz Herko, manager of electronic systems at Kennametal (Latrobe, Pa.). This complicates the sensing problem; sensors must respond to several phenomena rather than to a single input indicating an abnormal tool state.

In-cut sensing systems on the market today measure either cutting forces or spindle power. According to Herko, direct cutting forces (measured near the tool tip) provide the most sensitive information about tool condition. They provide a clear and recognizable signal of low distortion and high bandwidth. Still, because the cutting force is directly affected by tool geometry, cut cross section, and metal removal rate, it is difficult to extract useful information from the transducer signal.

As a way around this predicament, most systems resort to some form of setpoint technique. At a predetermined signal level, the cutting tool is changed.

Untended machining center configuration is illustrated by this Kennametal design. Process-dependent factors would be monitored by transducers, tool positioning by a vision-based sensor. Computer equipment to control the system would be located elsewhere in the plant.

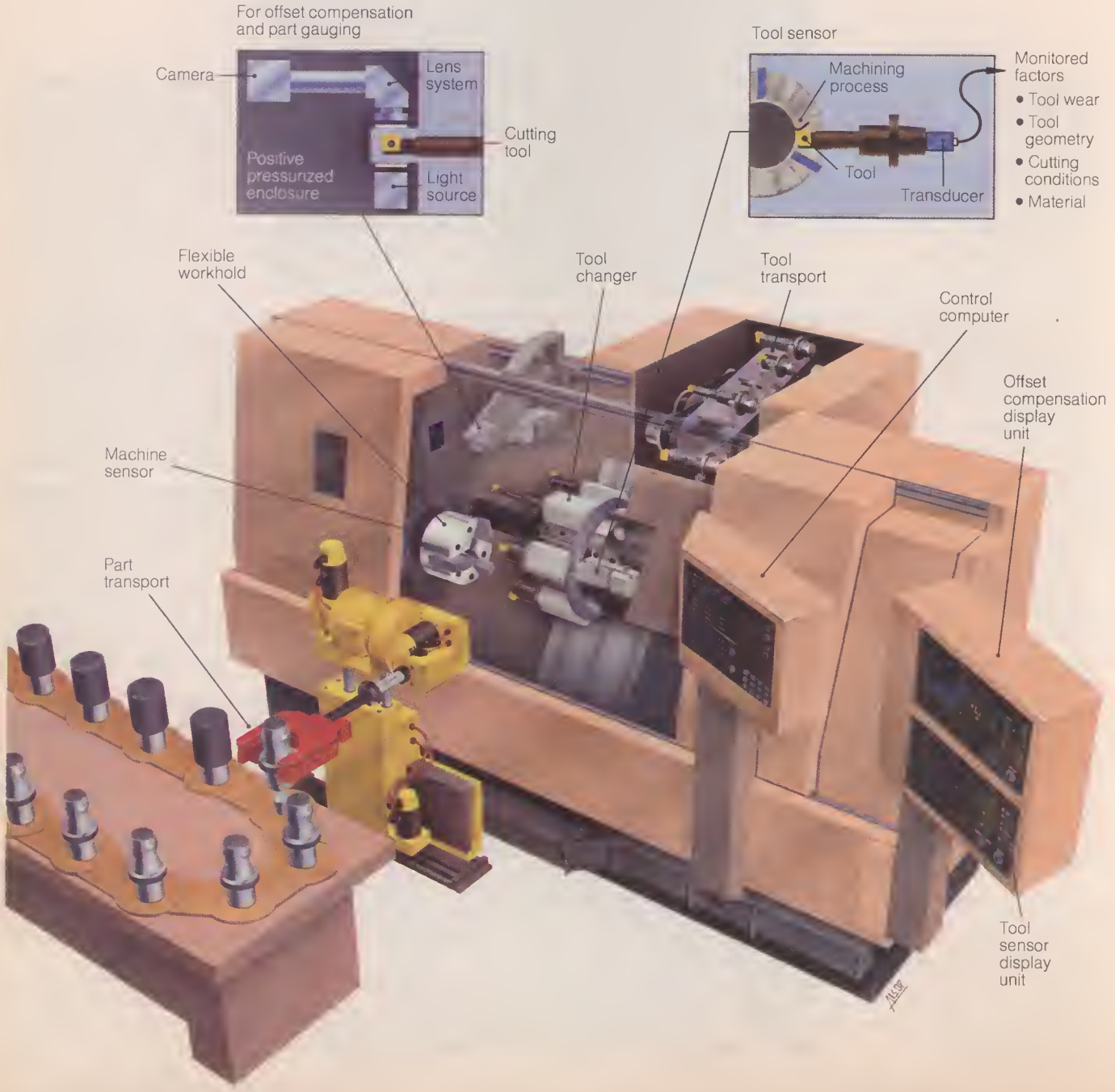
In some systems, a different threshold is set for each stage of the part's numerical control program. That is, a much lower threshold is set for light finishing cuts than for heavy roughing cuts, allowing the finishing operation to be monitored with greater accuracy.

The multiple threshold approach works fine for simple parts. Complex numerical control programs, though, require a great deal of data to set limits for each machine feed motion, and "most users lack the database from which this reference signal level can be easily extrapolated," says Herko.

So some of the new systems must cheat a little by taking sample cuts to set normal threshold levels (the "teach" method). For subsequent parts the signals are allowed to exceed the normal values by a certain margin—say, 20–30%. This information is then recorded and saved.

Because machining processes vary greatly, however, these systems aren't always successful. In some cases, cutting forces may safely be four times the normal signal without endangering the tool, machine, or workpiece; in other cases, even a 20% variation may pose a serious problem.

A considerable amount of trial and error is therefore needed to set reasonable threshold values. If the values are too close to the normal values, there will be many false alarms; if set too far from the norm, there will be too few alarms and damage may occur. In spite



of this drawback, says Milacron's Kegg, threshold sensing systems are growing in popularity.

Establishing a set point can be made easier by using pattern recognition to identify the important characteristics of the force signal. An algorithm can then be developed for sensing tool condition. Such a self-tuning system has recently been developed by Kennametal. In fact, the Kennametal system not only eliminates the need for sample cuts but also can monitor the condition of up to 60 cutting tools simultaneously, providing status reports on the condition of each tool.

If the signal indicates a worn cutting tool, the system allows the machine to continue to the end of the run. At that point, the machine stops and the tool is changed. But if the signal indicates that the tool is broken, the machine immediately retracts it and changes both the tool and the workpiece.

Two other promising methods of sensing tool wear rely neither on force nor on power but on vibrations and sounds produced by the tool as it cuts. The vibration pattern of a worn or broken tool differs from that of a fresh one.

Unfortunately, anything else that's moving on the machine—from the spindle drive to the hydraulic pumps—is also creating distinct vibrations. Even the clatter of nearby machines will be part of this jumble. These extraneous signals must be filtered out.

The National Bureau of Standards (NBS) in Gaithersburg, Md., may have an answer. Its Drill-Up system for detecting worn drills is based on a technique called synchronous vibration analysis. Drill-Up tracks the peak vibrations that occur during every revolution of the drill, while ignoring extraneous signals. As the drill wears, the peak vibration gets stronger. When a set point is reached, the drill is retracted from the workpiece and is replaced. So far, Drill-Up's most successful performance has been with long, thin drills, but NBS scientists believe that the process should work for milling centers or any multipoint tool as well.

Acoustic emission (AE), another sensing method, has been highly promoted in the field of nondestructive testing (HIGH TECHNOLOGY, Feb. 1984, p. 49). Now, pioneering work is being done at the University of California (Berkeley) and at the University of Michigan in using AE to sense tool wear.

The principle behind AE monitoring is the detection of the faint, high-frequency sounds emitted by the cutting tool as it begins to break. These sound waves, caused by the release of elastic energy, consist of discrete pulses that propagate outward. As with vibration analysis, the biggest challenge will be in developing suitable filtering techniques and algorithms to isolate the signal from background noise. Fortunately, the pulse rate and amplitude of an AE signal are quite high compared with the usual noise emanating from tools, so it should be fairly easy to identify. AE tool-breakage monitors will be available soon, as either stand-alone or embedded systems, reports David Gee, research engineer at Warner & Swasey (Cleveland).

In addition to sensors for tool wear and breakage, systems known as between-cut monitors are being developed to ensure that the accuracy of the entire machining operation is maintained throughout a production run. These are probing systems designed to automatically adjust tool offsets (differences between the location of the cutting edge of the worn tool and that of the replacement tool) and to insure that the parts are being produced within tolerance.

These systems mark a radical shift in the whole notion of quality control, says John Simpson, director of NBS's Center for Manufacturing Engineering. Simpson considers the ritual of inspecting finished parts antithetical to the concept of automation. A better idea is to monitor the machine making the parts. "If you don't let the process change,

GE's electronic monitoring system checks the dimension of the workpiece and automatically adjusts depth of cut. The company plans to adapt the system, which is based on vibration signal analysis, to the detection of broken tooling.

The measurement of cutting forces provides a sensitive indicator of a tool's efficiency, says Kennametal's Herko (shown with the company's tool condition sensor).

Toward the cellular machine shop

Before the '70s, most machine tool departments were segregated by machine type. Lathes were grouped in one area of the shop, milling machines in another, grinding machines in yet another. Parts spent nearly half their production time being carted around the shop.

Recently there has been a shift toward the manufacturing cell, in which different machines are grouped together in production lines to make complete parts. This arrangement reduces setup time, material handling, and floor waiting time. It also helps manufacturers to employ so-called group technology, or families-of-parts concepts.

This last advantage is receiving broad recognition within the metalworking industry. The National Bureau of Standards (NBS), for example, is setting up automated cells at its brand-new Automated Manufacturing Research Facility (AMRF) in Gaithersburg, Md. With funding of $6 million a year, one of its main objectives is to improve quality assurance techniques in an automated factory.

Much of the research will be aimed at developing generic technology using numerically controlled lathes, machining centers, robots, and other machines required for flexible manufacturing (the production of multiple parts by a single system). Standardization of machine controls, interfaces, and common programming languages will receive primary attention. "The AMRF will provide a test-bed for research directed toward establishing standard practices," says John Simpson, director of NBS's Center for Manufacturing Engineering.

The high degree of interactivity between machines in flexible manufacturing systems poses an enormous controls challenge. The problem of automatically controlling a number of feedback-driven machine tools is far greater than the sum of the control problems of the individual machines. This is the point at which most of the early attempts at building the automated machine shop failed, says Simpson.

NBS's solution was to divide up the problem, employing some type of hierarchical control—that is, a computerized system in which a problem is broken into subproblems that are then dealt with in decreasing order of urgency. Hierarchical control is not new to industry; it has long been employed in process plants such as steel mills and oil refineries. But usually, says Simpson, such hierarchies have only two or three levels and represent fairly straightforward servocontrol applications.

JOHN NEUBAUER

By keeping the milling process constant, machine monitoring systems will make it unnecessary to inspect finished parts, says Simpson of the National Bureau of Standards.

The unique features of the control system being planned for the AMRF are the number of hierarchical levels (as many as eight) and the amount of real-time computation, along with sensory interactions, at each level. The plan is to build a real-time interactive control system that uses tight servo loops to respond to events of milliseconds' duration. At other levels, the system will deal with activity extending over days or weeks—production planning and scheduling, for instance.

Dozens of computers, ranging from the DEC VAX-11/780 master computer to on-board microprocessors monitoring the individual sensing systems, will make the AMRF a truly flexible manufacturing system. With computers becoming the linchpin of the factory of the future, the nation producing the best software to feed this mechanical army will gain leadership on the factory floor. Indeed, it is in software that many observers believe the U.S. has a clear edge. "So far," says Simpson, "the Japanese have failed to focus on the software aspects of factory control."

then you don't need to inspect individual parts later," says Simpson.

Touch probing systems are gaining wide acceptance as a way to check tool position. One example, developed by Valeron (Troy, Mich.), uses an infrared signal to periodically inspect both the cutting tool and the workpiece. When the probe makes contact with the tool or workpiece, an infrared signal flashes measurement data to a nearby receiver that converts the light into an electrical pulse. The pulse is picked up by an interface board connecting the monitoring system to the machine control.

Kennametal has taken another approach, substituting vision for touch sensing. The machine tool is programmed to position the worn cutting tool in front of a sealed camera in the sensing element. The visual image is translated into a binary image consisting of 256 × 256 pixels. The sensor analyzes where the cutting edge is relative to where it should be, and transmits the results to a CNC (computerized numerical control) offset device that then makes necessary corrections. Kennametal claims that its tool offset sensor is accurate to within 0.0004 inch.

Because temperature variations can be a major contributor to faulty workmanship in precision machining, Cross & Trecker (Milwaukee) has developed a prototype monitoring system that automatically compensates for errors caused by the thermal expansion of the slideway (the metal bed that holds a workpiece). Called automatic dynamic error compensation, the system uses heuristic programming, or a set of guidelines rather than a precise sequence of steps. This approach enables the system to learn over time, reports Paul Haas, vice-president and general manager of the company's special products division. The system is about a year away from making its commercial debut, he says.

For all its promise, of course, untended machining remains largely experimental. Nevertheless, the combination of sensing and control technology now being developed will go a long way toward allowing automated machining centers to operate reliably—and productively—on their own. □

Ernest Raia is a former senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES** *on page 74.*

Sensors guide the way for machine tools

Sensors are a relatively small portion of the machine tool industry, but they are intimately connected with both the future of the factory and the fate of domestic machine tool manufacturers. Sensors gather information on the wear and tear of machine tools and determine the location, dimensions, and condition of metal parts being cut or shaped by tools. These data provide essential inputs for automated machine control and monitoring.

The annual market for machine tool sensor systems is $25–50 million, estimates Paul Mueller, market development manager of GTE Valeron's Digital Techniques Division (Madison Heights, Mich.), a sensor supplier. It is difficult to be more precise, because sensors are frequently sold as part of a package by such machine tool vendors as Cincinnati Milacron, Kearney & Trecker (Milwaukee), Giddings & Lewis (Fond du Lac, Wis.), Ingersoll Milling Machine Company (Rockford, Ill.), and the Pratt & Whitney Machine Tool Division of Colt Industries (West Hartford, Conn.). Machine tool firms may either purchase sensor components from third parties or produce in-house systems.

Among the leading independent suppliers of tool-condition and part-measuring sensors are British-based Renishaw Electrical Ltd. (with a U.S. office in Arlington Heights, Ill.), known for its inductive touch-trigger probes, and GTE Valeron (Troy, Mich.), which produces infrared probes and a device for measuring spindle power. General Electric's Apparatus and Engineering Services Operation (Cincinnati) offers a touch probe sensor that uses acoustic emission techniques, and a laser-based inspection system is available from Automatrix (Dayton). Macotech (Seattle) sells an adaptive control system that measures tool spindle displacement and power draw, while Kennametal (Latrobe, Pa.) produces a vision-based cutting tool positioner and a tool-condition sensor.

Touch probes have gained widespread acceptance among machine tool users in the past 15 years, and other systems have entered the market more recently. Although sensors are not yet standard features on machine tools, vendors tend to offer them as options. For example, Bernard Howaniec, VP for sales at Kearney & Trecker, reports that 70% of his company's customers buy equipment with sensor options, which are a relatively small proportion of the cost of a sophisticated machine tool. He adds, "This type of feature gets us orders."

Hall

Carter

"Sensors are part of the evolution of machine tool products. As machines get more complex, sensors come to dominate."

Harry Hall, President
General Purpose Machine Tool Division
Giddings & Lewis

"With sensor aids, you can reduce scrap, compensate for dimensional change, keep the machine producing a higher proportion of the time, and gain a higher quality of work."

Charles Carter
Technical Director
Cincinnati Milacron

Given the battering taken by the U.S. machine tool vendors in recent years, much of this activity might at first appear to be too little, too late. Foreign competition has been fierce, and the recession caused a slowdown in capital investment by the industry's customers in automotive, agricultural, and other hard-hit manufacturing sectors. As a result, says Joseph Franklin, statistical director at the National Machine Tool Builders Association (Washington, D.C.), "a quarter of the domestic machine tool industry has disappeared in the past four years."

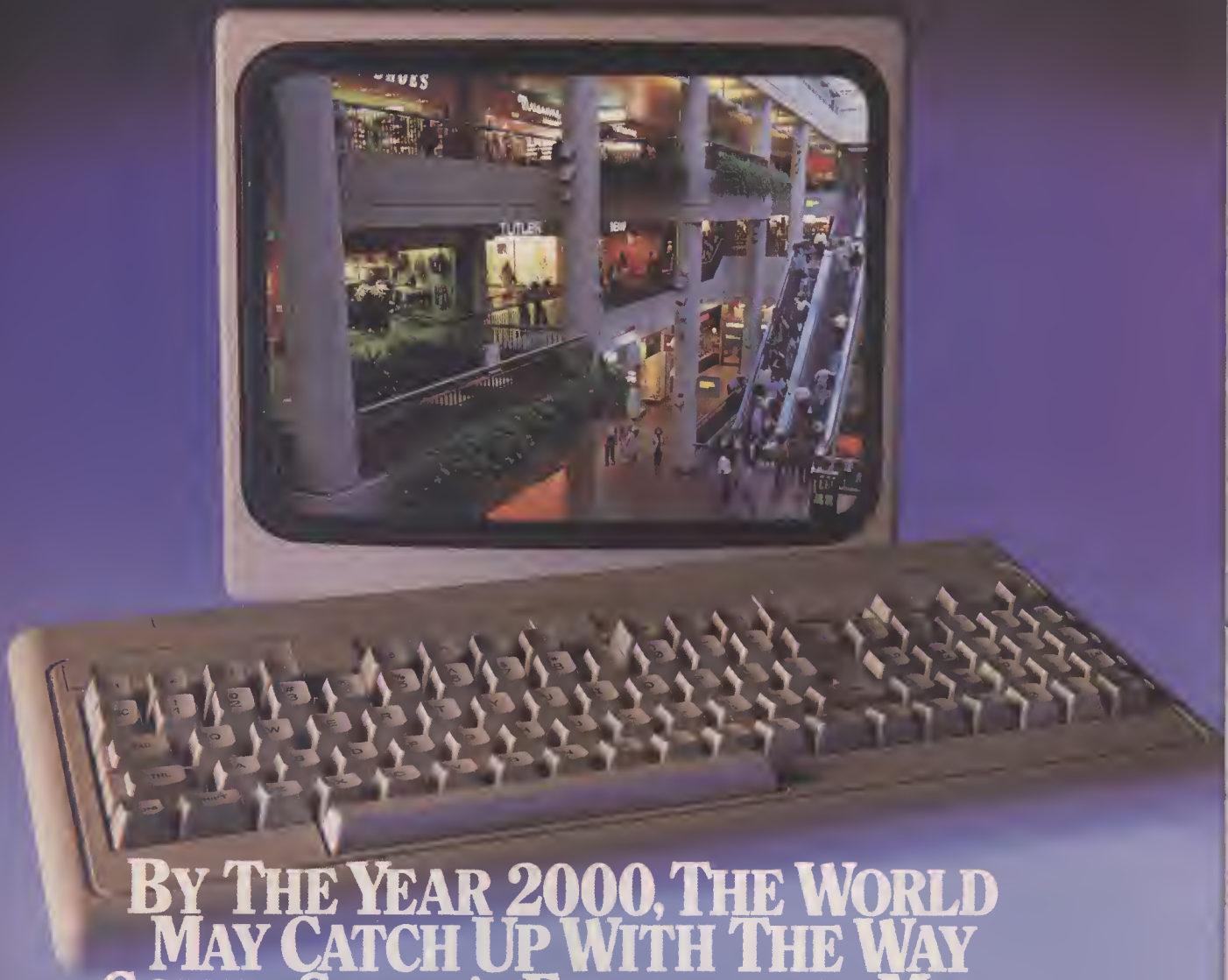
Even though the economy is now more active, U.S. vendors will not necessarily get more orders. Overseas suppliers accounted for almost half of the $2.3 billion in machine tools sold in the U.S. in 1984, buoyed by the strong dollar, efficient production methods, and quick delivery. Half of those imports were from Japan.

Nevertheless, Valeron's Mueller believes that the market for sensors, and the sales prospects for U.S. vendors, are on the verge of rapid growth. Sensors are riding two important waves linked to the general rise in demand for more and higher-quality automated machine tools.

One involves steps taken by U.S. machine tool companies to increase their share of the domestic market. Since much of the imported equipment consists of relatively unsophisticated, general-purpose machine tools, "everyone is differentiating their products from the low-cost manufacturers by adding on electronic components," says Christine Chien, factory automation analyst at Prudential-Bache (New York).

But do domestic machine tool users really want high tech milling machines, grinders, and lathes? Apparently. According to Clifford Young, senior consultant at Arthur D. Little's Computer Integrated Manufacturing Group (Cambridge, Mass.), 35–40% of the machine tools now sold by U.S. firms are computer-controlled. This sector is also growing faster than the machine tool field as a whole. Demand for advanced equipment is growing as manufacturers become convinced that machine cells and flexible manufacturing systems are more efficient in turning out medium-batch runs of diverse parts than are stand-alone machines. Even operators of transfer lines are considering the utility of computerized machines for making families of parts and for avoiding the expense of future retooling. (In transfer lines a part is manufactured in high volumes by a series of specialized conventional machines.)

The capital invested in a computer-controlled machine is most productively recovered if the machine can be run as close to 24 hours a day as possible. That implies less use of human operators and increased reliance on sensors. "To go to untended manufacturing, you have to know in real time how the machine is performing and what its condition is," says Charles Brown, manager of advanced machining systems at Kennametal's Machining Systems Division (Raleigh, N.C.). "Sensing is the bridge between the present and that kind of operation."***—Dennis Livingston***



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LOUDSPEAKERS: IN SEARCH OF HIGHER FI

Ribbons and plasma drivers could make conventional speakers obsolete

Loudspeakers have long been the weak link in high-fidelity audio systems. But now the precision and clarity of sound made possible by modern recording technology is fueling consumer demand for a comparable improvement in loudspeakers. In order to meet this goal, a revolution in speaker design is getting underway.

For the past several decades, loudspeaker drivers—the actual sound-producing elements—have usually consisted of cones or domes made of stiff paper. But alternative speaker technologies, including mechanical-acoustic devices known as ribbon drivers and nonmechanical systems such as plasma drivers, offer significantly higher fidelity. While experimental prototypes of both systems date back to the 1920s, commercial speakers incorporating these systems have only recently begun to reach the market.

All loudspeakers are transducers—devices for converting electrical energy from an analog signal into acoustical energy (sound). Most systems do this in two steps: Electrical energy is converted into mechanical energy and then into acoustical energy. With cone drivers, the conversion is mediated by a simple motor assembly consisting of a permanent magnet and a coil of conductive wire. An audio amplifier transmits to the coil an alternating current with frequencies equivalent to those of audible sound waves. This signal intermittently magnetizes the coil, causing the cone to vibrate back and forth at audio frequencies to produce sound. The cone is therefore analogous to the piston of a superfast motor, operating at speeds of 20 to 20,000 hertz (cycles per second).

by Daniel Sweeney

High-end Jumetite loudspeaker has a 3-inch ribbon driver (inside top module) with a range down to 600 hertz and two 10-inch cone drivers for lower frequencies.

Cone speakers (as well as domes) have several inherent liabilities. Because the cone is driven only at its apex, it is subject to flexing and flapping at higher speeds. These bending modes, which are impossible to control completely, set up spurious vibrations that interfere with the accurate reproduction of sound. Cones several inches across are required for producing powerful low bass—but the wider the cone, the lower the frequency at which the bending modes occur. Trying to control the bending modes by reinforcing and stiffening the cone makes it more massive, creating inertial forces at high frequencies and hence limiting treble response.

An ideal loudspeaker would use a single driver. But since cones perform rather badly beyond a four-octave range, they are not suited to the full spectrum of frequencies. Thus, for optimal fidelity, conventional speakers usually contain three or even four cones or domes of various dimensions. In such multidriver systems, an electronic filter splits the electrical input from the amplifier into separate frequency bands, routing each to the appropriate driver. Unfortunately, the filter inevitably degrades signal quality, and the drivers exhibit varying degrees of acoustic mismatching.

The ribbon loudspeaker avoids many of these limitations, since a single ribbon driver can be operated with minimal distortion over a frequency range of five octaves (half the audible spectrum), reducing the number of drivers to two. A ribbon loudspeaker is a remarkably simple mechanism, consisting of an accordion-pleated strip of superthin aluminum foil (2–10 microns thick) suspended loosely between the poles of a powerful magnet or a series of magnets placed side by side. The foil conducts electrical current from the power amplifier and is magnetized in the same manner as the coil in a cone loudspeaker: Alternating current shifts the polarization of the magnetic field, which in turn generates attractive and repulsive forces relative to the field of the permanent magnet(s). These forces cause the metal strip to vibrate and generate sound.

The movements of the ribbon are

precise analogs of the fluctuations in the signal current. Ribbon mass and the consequent inertial effects are a tiny fraction of those of cone speakers, and the driving forces are nearly uniform over the surface. A ribbon exhibits certain uncontrolled vibrations in the form of traveling waves that move up and down its length, but these waves can be effectively dampened by placing a spongy material at the ends of the ribbon, or by depositing the ribbon on a thin plastic film backing. Still, ribbons are not ideal transducers: No single ribbon driver can operate over the full frequency range from low bass to high treble.

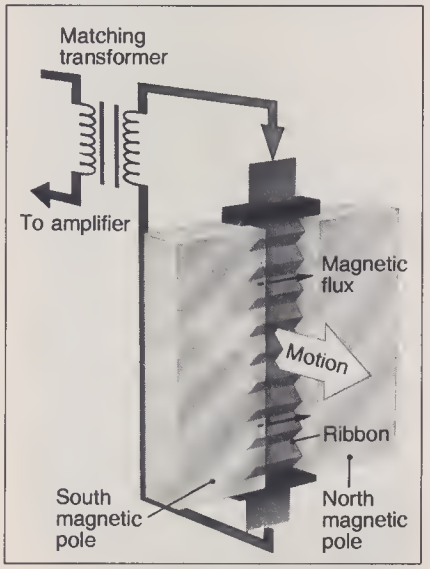
There are other systems with similarly low mass and uniform distribution of forces. Electrostatic and planar-dynamic speakers have been used in high-fidelity applications for decades and may exceed the performance of ribbons in terms of frequency range and freedom from inertial effects. But they have their own set of drawbacks. These speakers, which employ thin plastic diaphragms stretched between high-voltage electrodes, are difficult and costly to manufacture—requiring many hours of skilled labor—and they have certain performance limitations. Their major flaw is that after the plastic diaphragm deforms in response to an audio signal, it returns to its initial dimensions relatively slowly, releasing acoustic energy that is out of phase with the music signal.

Given the advantages of ribbon drivers and the fact that the technology was patented back in 1925, one might ask why ribbons have not seen greater application in loudspeaker systems. Although speakers with ribbon drivers have been sold on a limited basis since the 1940s, they have until recently been confined to use as high-frequency tweeters. The main obstacles to using ribbons for broader portions of the audio spectrum have been reliability problems and high manufacturing costs—more than $1000 a speaker. For example, in order to generate frequencies in the middle of the audio range, a ribbon must be several inches long, necessitating a massive and very expensive magnet to drive it and a high-quality audio transformer.

Heat dissipation is another problem with ribbon drivers, since they are inefficient conductors and generate a lot of waste heat. Aluminum, the material of choice for speaker ribbons, has a low melting point and deforms permanently at temperatures considerably below this level. Unlike cone speakers, ribbons cannot be cooled with ferrofluid and hence must dissipate excess heat to the surrounding air. Thus, unless the ribbon has an enormous surface area, it cannot handle continuous high wattages.

Today, thanks to declining magnet costs and refinements in design, the economics of ribbon speakers are improving. Two basic magnet designs are currently in use. Jumetite Labs (Vancouver, B.C.) has developed a $3000 system with a single large horseshoe magnet and a 3-inch ribbon that radiates sound into a horn structure connected to the magnet. The output of this ribbon, especially in the middle range, has been raised to the point where continous sound levels of 106 decibels are possible. (In contrast, early commercial ribbons were extremely fragile and tended to self-destruct as they approached 100 decibels.) An elaborate servo circuit monitors the temperature of the ribbon and prevents it from overheating by limiting the current when a certain temperature is exceeded.

An alternative approach to ribbon speakers has been taken by three companies: Magnepan (White Bear Lake, Minn.), Apogee (Norwood, Mass.), and VMPS (El Cerrito, Cal.). These firms employ ribbons several feet long, which are suspended vertically between the poles of a stack of horseshoe magnets. In the Apogee and the Magnepan designs, the yokes of the magnets are separated by air spaces, permitting sound to be propagated from the back of the ribbon as well as the front. In the VMPS speaker ($7500) the magnets abut one another, and the space behind the ribbon is packed with sound-deadening material.



A ribbon loudspeaker driver is a strip of aluminum film 0.00025 inch thick, suspended in a magnetic field. An electrical input current from the audio amplifier flows through the ribbon and reacts with the magnetic flux, causing the ribbon to vibrate and produce sound.

MARK E. ALSOP

The Magnepan speakers ($1950–$2950) use a ribbon driver only for frequencies over 2000 hertz, roughly an octave above high C. The VMPS speaker employs a single ribbon from 300 hertz (around the E-flat above middle C) to 15,000 hertz, near the limit of human hearing. The Apogee speakers ($3500–$6600) employ three ribbon drivers: one for deep bass, a second for the lower midrange, and a third for higher frequencies. Although ribbon speakers are quite costly at present, Jumetite president Ted Hobrough believes that they may eventually be mass-produced for only slightly more money than cones.

Massless drivers, which agitate the air with a plasma (a gas containing charged particles, or ions) rather than a mechanical diaphragm, offer superior performance to ribbons or any other design, although the technology remains extremely expensive. At least eight types of massless drivers have been developed, but only one approach, known as thermodynamic coupling, has been incorporated into a commercial speaker.

Thermodynamic coupling involves an electrical phenomenon called corona discharge—the generation of a glowing mass of ionized air by a high-energy electric field. In the early part of this century, sound-producing corona discharges known as singing arcs were observed at breaks in the insulation of high-voltage radio circuits. This phenomenon was subsequently applied in experimental loudspeakers.

It wasn't until 1950, however, that Siegfried Klein, an expatriate German physicist living in France, demonstrated the first practical model of a plasma-driven loudspeaker. The two surviving descendants of Klein's design are the Magnat, made by Magnat Electronik (Cologne, West Germany), and the Hill System I, made by Plasmatronics (Albuquerque). In both speakers, a constant electric current—alternating in the Magnat, direct in the Hill

System I—charges a pair of electrodes until a corona discharge occurs. This discharge heats the air around the electrode, creating a cloud of plasma that forms a sharp thermal boundary with the surrounding air.

The constant current is amplitude-modulated by an audio signal, which induces corresponding fluctuations in the temperature of the plasma cloud. This changing temperature causes the plasma cloud to expand and contract, generating pressure waves that are manifested as sound, much as the sudden heating of air by lightning produces thunder. Although plasma drivers are sometimes referred to as "ionic" loudspeakers, this term is a misnomer because the ions in the plasma do not play a direct role in sound production.

The Magnat speaker is a simple design with a small plasma cloud that does not operate below 4000 hertz. It serves as a tweeter in an otherwise conventional loudspeaker system, and is available in Europe in an add-on version for about $1000 a pair. Unfortunately, the Magnat generates ozone at potentially unsafe levels.

The Hill System I is far more elaborate. It requires industrial helium tanks and special high-voltage amplifiers for operation, and costs about $10,000 a pair by special order. The plasma cloud surrounding the electrodes is about an inch wide and has an approximately pyramidal shape. Helium gas flowing from a valve next to the electrodes varies the density of the plasma, extending the speaker's response into the midrange. The helium also cools the plasma rapidly for extended high-frequency response. (Since the sound is produced by variations in temperature and pressure, the drop back to equilibrium temperature must be very fast.)

The Hill driver avoids traveling waves and other mechanical resonances, and produces negligible distortion. Measurements of sound amplitude, phase, and distortion are superior to those of any other driver over an equivalent frequency range; the speakers can also generate extremely high continuous sound levels, well over 120 decibels. Nevertheless, operation over the full range of audio frequencies is not yet practical. The system operates at up to 200,000 hertz (three octaves above the limit of human hearing) and down to 700 hertz. Below this frequency, ordinary cone drivers are used. Despite the system's high cost, inventor Alan Hill maintains that a mass-produced version of the speaker could be sold for about $2000.

Full-range ribbon loudspeaker by Apogee Acoustics covers the entire audio spectrum by assigning three separate ribbon drivers to bass, midrange, and treble regions. The speaker cabinet is unusually tall and thin—57 inches high and 3.5 inches deep.

Several experimental models of plasma drivers can reproduce the full range of audio frequencies. Although these systems promise virtually perfect sound reproduction, none is commercially feasible. Developing marketable models will require a major R&D effort, but none of the leading audio companies has yet expressed interest in making the investment. Still, as digital audio becomes more widespread and public demand for high fidelity increases, the loudspeaker industry is bound to realize the limitations of established designs and to seek out emerging technologies. So far, ribbons and plasma drivers are the best we have. □

Daniel Sweeney is a Los Angeles freelance writer specializing in audio equipment and consumer electronics.

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Fleets of robotlike devices that transport workpieces from one station to another are changing the basic nature of the assembly line in some U.S. automotive plants. This scheme, called an automatic guided vehicle system (AGVS), offers flexible-path movement of materials through assembly operations, a concept radically different from the traditional linear assembly line developed by Henry Ford at the turn of the century.

Several U.S. car makers are now using or installing these systems to improve productivity and quality. The world's first assembly line in which guided vehicles help join automotive engines with car bodies is already assembling 1985 front-wheel-drive Oldsmobiles, Buicks, and Pontiacs. At General Motors' Oldsmobile plant in Lansing, Mich., a central AGVS is used for engine assembly, and two pairs of systems in separate nearby facilities are used for installing major components. One system in each pair is used to merge the chassis with a car body moving overhead on a conveyor. The other is then used to install the engine and transmission assembly.

Don Downie, director of industrial engineering at the Oldsmobile plant, believes that the AGVS will result in quality improvement. "Every assembler is free to hold the work at his station until he's satisfied the work is done correctly," he says. "Repairs can be made in-station instead of downline. We expect our workers will take more pride in their work since we're giving them complete control of their assembly steps."

Each vehicle in the Lansing systems is guided by an electromagnetic field generated by a wire buried in the plant floor. The wire, or guidepath, emits a fixed, low-frequency ac signal that is tracked by sensors on the bottom of the vehicle. Bumpers automatically stop the vehicle on contact with another object, preventing injury to people working in the AGVS area. Movement is controlled by a Digital Equipment Corp. PDP 11/44 minicomputer, which communicates with a microprocessor on each vehicle. When an engine is first loaded onto a vehicle, a worker passes a hand-held laser scanner over a bar code label on the engine to identify it for the minicomputer. The worker then uses a keyboard to enter the identification number of the guided vehicle into the PDP 11/44's memory. From that point on, the minicomputer knows which engine is where, and can dispatch each guided vehicle to appropriate assembly workstations. The microprocessor on the guided vehicle constantly updates the PDP 11/44 as to the vehicle's whereabouts.

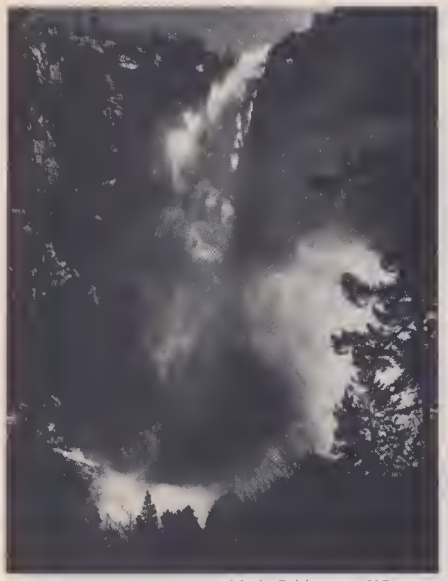
Compared with linear assembly lines, AGV assembly systems are more economical for products with many models or options, such as automotive engines, but less economical for large numbers of the same part or product. They also impose different production requirements. For example, a large amount of stock may have to be stored at each workstation. As an alternative, containers of the required parts can be loaded onto the guided vehicles by robots at special parts-provisioning stations between workstations. In addition, AGV assembly systems typically require 10–15% more space than an overhead conveyor system. Nevertheless, they cost substantially less to accomplish the same task.

Although AGVS technology was created primarily in the U.S., European companies developed and expanded its applications, first in warehouses and then in factories. The vast majority of assembly applications have been in the automotive industry. Volvo in particular has been a pioneer in applying AGVS to assembly operations. In 1975, the Volvo plant in Kalmar, Sweden, was the first automotive assembly operation wholly committed to the use of AGVS, with two separate systems employing more than 400 guided vehicles. Volvo claims that AGVS has markedly increased plant productivity

At Oldsmobile's plant in Lansing, Mich., automatic guided vehicles carry completed engine assemblies and raise them to meet with car bodies moving on an overhead conveyor.

EATON-KENWAY

by Stephen Barabo



Bridalveil Fall, Yosemite National Park, California c. 1927. Photography by Ansel Adams. Courtesy of the Ansel Adams Publishing Rights Trust. All rights reserved.

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Special-purpose guided vehicles made by Volvo, a pioneer in AGVS design and application, are used at the Fisher Body plant in Lansing, Mich., to carry car bodies to a robot line for window and trim installation.

and product quality. Other European automakers, such as Opel and Fiat, have also used these systems for years.

In the U.S., however, car makers are only now beginning to adopt AGVS technology in their assembly plants. In addition to the Oldsmobile system in Lansing, GM's Buick Division (Flint, Mich.) recently installed a system, and GM's Fisher Body assembly plant in Lansing is installing one in which robots will attach glass components to car bodies as they rest on guided vehicles.

The guided vehicles for the Oldsmobile system were built by Eaton-Kenway (Salt Lake City). Because Oldsmobile's needs exceeded the manufacturing capacity of Eaton-Kenway, some vehicles were made by Digitron of West Germany, which has licensed Eaton-Kenway to manufacture its AGVS in the U.S. Other domestic suppliers of AGVS for assembly include Portec's Navigator Division (Oak Brook, Ill.), Conco-Tellus (Mendota, Ill.), Jervis B. Webb's affiliate Control Engineering (Farmington Hills, Mich.), and Volvo of America's Automated Systems Division (Sterling Heights, Mich.), which supplied Fisher Body's AGVS.

Although automotive plants have dominated AGVS assembly applications, the technology is by no means limited to one industry. International Harvester has used guided vehicles in assembling tractors at its Farmall plant in Rock Island, Ill., and according to Portec, an appliance manufacturer in Europe is installing a system for assembling washing machines.

Electronics manufacturers have also expressed interest in AGVS for assembly, although the guided vehicles will most likely be used to pick up work at one station and drop it off at the next (in contrast to most automotive applications, in which each part rests on the guided vehicle throughout the assembly process). This approach has been applied at one of Teledyne's assembly facilities in Lewisburg, Tenn.

Whatever the future of AGVS in other industries that perform assembly, U.S. car makers now appear sold on the technology. "I know that several more GM divisions are planning to use AGVS in their assembly operations," says Oldsmobile's Downie. "I believe it's the wave of the future for our industry." The recent rush by U.S. companies to apply AGVS in their assembly operations may signal a turning point in their struggle to recapture their share of the world automotive market. Material-handling systems such as AGVS have the potential to give U.S. car makers sufficient manufacturing flexibility to push them past their Japanese competitors. □

Stephen Barabo, an editor and writer in Boston, follows industrial technology.

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HT65

VOICE/DATA STATIONS SEARCH OUT A MARKET

Units that merge terminals, PCs, and phones show promise despite a rocky start

This market was supposed to dwarf all others for data terminals. Computer workstations that pulled together telephone, data terminal, and personal computer functions in one relatively inexpensive box seemed to solve so many problems for so many users that buyers were supposed to beat paths—virtual freeways—to the vendors' sales outlets. But this scenario never materialized; years after the first products—integrated voice/data workstations, or IVDWs—hit the market, they are still struggling to establish a beachhead on the budgets of data processing and communications managers around the world.

Workers whose jobs require them to access both corporate and external data resources often need more than one computer terminal, as well as the everpresent telephone. Two terminals are necessary because many corporations use IBM computers, which employ a communications protocol different from that of most remote computing data resources. Workers may also require the local processing power of personal computers.

PCs alone rarely fill the bill. Most provide no communications functions—only 20% of the personal computers sold during 1984 were sold with modems, estimates Arthur D. Little (ADL—Cambridge, Mass.), a market research and consulting firm. Personal computers that provide terminal emulation for data communications usually employ only the ASCII asynchronous protocol, the non-IBM standard. Some machines emulate IBM protocols (3270 bisynchronous or SNA/SDLC) for communications—but few offer both protocol standards, and none of them automates telephone functions.

IVDWs are designed to answer a range of communications needs. They can support 3270 bisynchronous, SNA/SDLC, ASCII, and telephone management (or some combination of those functions) all in one unit. In an attempt to meet virtually every user's demands, some IVDWs have also added personal computer functions to their repertoire.

The most visible distinction of IVDWs is their combination of a telephone with a computer terminal. But there may be a significant market for personal computer/data terminals that integrate processing and communications functions without physically integrating telephones, believes Martyn Roetter, a senior consultant on ADL's Information Systems staff. "Most professionals use their telephones and their personal computers separately," he says. "The footprint of a telephone isn't very large, so that's not a compelling reason to integrate the two, and most people already have a telephone, so why replace it? A data communications/personal computer workstation that is functionally integrated with a separate telephone could be as attractive as an IVDW combining data and telephone functions in one box."

Truly integrated workstations would allow users to retrieve data from local and/or remote sources, load it into a personal computer application (such as a spreadsheet), and then automatically dial the phone to discuss it with someone else. Unfortunately, the degree of integration varies from product to product, and the number of users who need such broad communications and computing power may be smaller than originally thought. So-called knowledge workers who must access a variety of data resources while talking with clients range from stockbrokers and insurance agents to customer service representatives. But even this seemingly surefire market has not yet taken to IVDWs in a big way.

Still, some major equipment manufacturers see a strong need for such terminals; about 25 companies have announced a wide range of IVDWs, and more are coming. IBM is rumored to be readying a product, and AT&T recently announced its Unix PC. And although actual sales remain at relatively low levels—less than $30 million in 1983—most analysts expect steady market growth. Market projections for the 1983–88 compounded annual growth rate range from a conservative 35% to a highly optimistic 193%.

One change that should help terminal manufacturers sell their systems is a reidentification of their target market. The first IVDWs introduced were expected to end up on executives' desks. But executives often don't type, and they rarely use personal computers or consult on-line databases; most spend their time communicating with their employees or evaluating data compiled by others. Corporate executives therefore represent a fairly limited market for IVDWs. The most likely candidates are professionals and customer service workers—people who spend much of their time on the phone referring to data displayed on their computer terminals. Manufacturers who have repositioned their products to go after such users find their sales increasing.

Another market factor that IVDW suppliers must face is the dominance of

Federico Faggin, president of Cygnet Technologies, with the firm's Communications CoSystem, which adds voice and data communications capabilities to IBM Personal Computers.

by H. Paris Burstyn

IBM's Personal Computer in today's office environment. Users will buy either a phone and a personal computer or an IVDW, but not both.

Some IVDW vendors are attempting to capitalize on the demand for IBM PCs by offering PC compatibility along with the other functions of their systems. In fact, Compaq Telecommunications (Dallas)—a wholly owned subsidiary of Compaq Computer—believes that the installed base of IBM PC users provides a target for its new TeleCompaq PC-compatible IVDW. Compaq's strategy is to sell its IVDW to current PC users, who would then give their used PCs to underlings. But asking companies to increase the penetration of PCs at a time when most corporations are requiring detailed justification of computer purchases could prove a risky strategy.

IVDWs exist in a variety of configurations. Some provide data terminal and telephone management facilities; others add personal computing capabilities to these functions; and a third group adds data communications and telephone features to installed personal computers, thereby taking advantage of machines already in use. Still, most share certain functions. In a single unit, IVDWs incorporate a CRT screen, a telephone, an ASCII keyboard, a modem, and communications software that provides last-number redialing, call-detail recording, calendaring, and access to electronic mail and remote databases.

Starting with basic telephone functions, IVDWs incorporate a handset and touch-tone pad and go on to provide auto dialing, telephone number directories (electronic Rolodex systems), as well as a host of telephone management features like automatic messages (when calling between similar IVDWs) and call timing so users know how much time and money they're spending on calls.

Some of these features may at first sound frivolous. But auto dialing makes a lot of sense for people who must frequently dial long strings of numbers, whether for long-distance access or for in-house call billing. And it's surprisingly nice to be able to scroll through an electronic Rolodex, find a name, and push a button or two to command the system to dial the phone. If unanswered, the call can be disconnected or a message left with the stroke of a few more keys. Most of the systems capable of leaving messages send the electronic equivalent of the ubiquitous pink "while you were out" message slip. Such systems automatically fill in caller, recipient, date, and time and can be set up to leave a "please call back" message.

Compaq Telecommunications' TeleCompaq consists of an industry-standard personal computer with voice and data communications capabilities.

Most IVDWs are said to be compatible with the major telephone private branch exchanges (PBXs), but that doesn't necessarily mean a system can be plugged in and used immediately. In some cases, especially where the IVDW replaces a multiline phone, a new line must be installed to allow users to take advantage of all the terminal's features. "It's going to be tough for manufacturers to be compatible with both IBM and every installed PBX," says ADL's Roetter. "It may be more reasonable to develop a product that is compatible with the majority of PBXs and to allow the PBX [rather than the IVDW] to provide some of the automated telephone functions."

On the data side, IVDWs provide a wealth of functions. Most emulate both ASCII-based terminals such as the VT-100 from Digital Equipment and EBCDIC-based terminals such as IBM's 3270 (for bisynch and SNA communications). IVDWs also provide a printer port and a modem, programmable softkeys (whose functions change according to the application), some software (such as word processing, a spreadsheet, and a communications package), and diskette storage. These features allow IVDWs to handle a variety of applications.

Davox relies on its DavoxNet local network to give its voice/data workstations access to an IBM PC, which provides processing functions and data storage.

Flexible though they may be, there are economic and technological barriers to be overcome before the market sees spectacular growth. Many users say the voice and data applications offered by current IVDWs are not really integrated so much as cooperative; users can employ the same terminal for voice and data applications but can't mix the two. Some IVDWs won't even combine data from two different sources.

As for economics, IVDWs range in price from less than $1000 to nearly $20,000, but their price tags do not always cover every feature or include the cost of implementing them through an office PBX or a local-area network. In some cases, the cost/benefit analysis still favors separate telephones, personal computers, and data terminals.

But forthcoming technical innovations should help boost the sales prospects for IVDWs. Multitasking IVDWs, like multitasking PCs, will allow users

to run and display simultaneous data processing applications in windows on the screen, switching between them as necessary. In addition, new systems allow users to transfer data between windows. Sydis (San Jose, Cal.), a manufacturer of high-end voice/data systems, even allows users to voice-annotate text documents and to store and send digitized voice messages.

Another development that may help IVDWs is the advent of integrated services digital networks (ISDNs). These will provide simultaneous digital voice, data, and image transmission over one cable and will promote IVDW use by overcoming the problems of integrating voice and data from different sources. Although until recently many industry watchers didn't foresee ISDNs arriving before the next century, the networks will start undergoing tests in the U.S. late next year.

In 1986, Ameritech (Chicago), the regional holding company providing local telephone service to Illinois and neighboring states, plans to test the United States' first commercial ISDN. It will be based on AT&T's 5 Electronic Switching System, a central office switch that provides a wide range of software applications. As the service matures over the next five years, it should provide subscribers with on-demand data transmission capacity between all types of computers that reside on any network (either local- or wide-area), a capability AT&T calls Universal Information Services.

The planned connection to this ISDN is through a plug no more complex than the modular jacks that connect telephones to the network. With an ISDN in place it will be easy to connect any terminal to the network and transparently access data no matter where it resides. A workstation that allows the viewing of multiple applications along with voice services will fit neatly into this environment, and IVDWs clearly provide the foundation for these functions.

Another force that will drive the acceptance of IVDWs is, surprisingly, real estate prices. In Manhattan, for example, office space for a standard five-foot desk rents for more than $1100 a year. At that rate anything that saves desk (and office) space will be increasingly welcome. Other forces are the decreasing reluctance of professionals to type, and the integration of voice communications in order to overcome the objections of users who don't want to type. Then, of course, there's AT&T's recent entry into the market, as well as rumors that IBM will follow. When these giants enter a new market, they lend a stamp of approval to it, and new growth can be expected. Witness the sharp upturn in the personal computer market once IBM introduced its PC; perhaps the same fate awaits IVDWs. □

H. Paris Burstyn is an analyst with the World Telecommunications Information Program at Arthur D. Little (Cambridge, Mass.).

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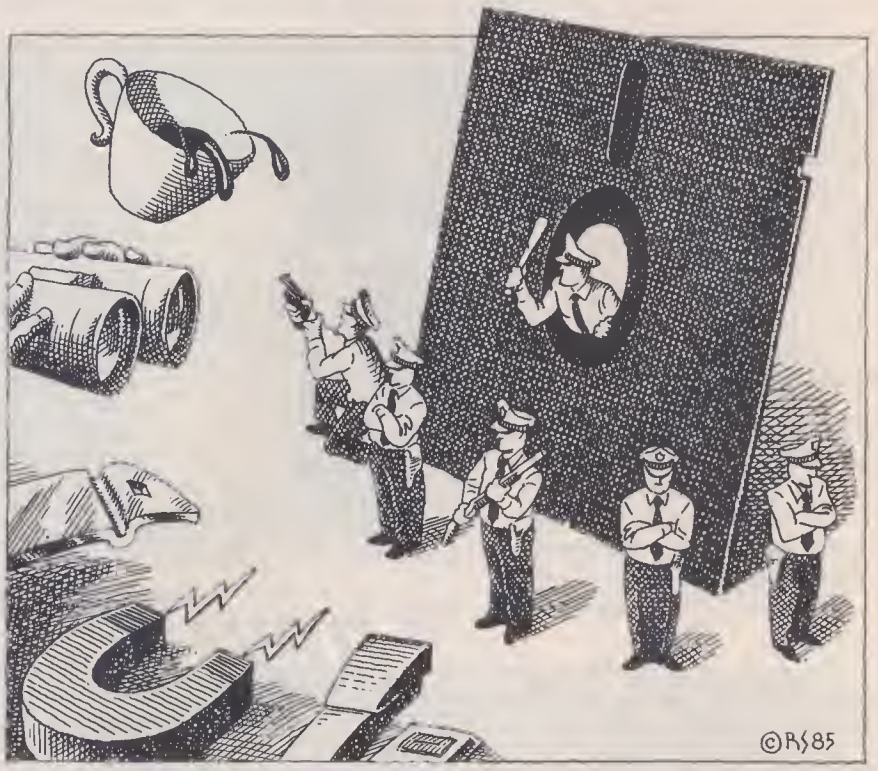
DEFEND YOUR DATA!

Some simple precautions can protect files from accidents and snooping



Whether it's the great American novel or a month's worth of order entries, the information stored in a computer is subject to threats ranging from accidental erasure to snooping. But because most single-user microcomputers are rarely connected permanently to communications lines, and therefore do not share the major data security problems of the time-shared mini and mainframe world, safeguarding information on microcomputers mostly calls for systematic common sense.

Accidental file loss is the most common hazard. Typically, an erase or delete command is issued inadvertently—either directly from the command line or indirectly through a program that automatically creates and deletes files. In many cases files can be recovered, because computer operating systems as a rule do not actually erase them. Instead they change a flag byte in the disk directory, freeing the space occupied by the file on the disk for new files. A map hidden in the directory specifies which sectors of the magnetic tracks hold the file information; the map is not changed by the flag byte. If no new information has been recorded over the tracks, the old information can be recovered by changing the flag byte back (the simple "undelete" programs do just this). If information has been recorded over all the same tracks, the file is lost forever. If new information covers only part of the tracks, then part of the file can be recovered.

Since tracks are not necessarily laid down sequentially but are often fragmented into many sectors scattered over the disk, recovery at this stage requires both a good sector-reading program and some knowledge and patience. The Norton Utilities program ($100) provides the tools for MS-DOS, including the ability to find a piece of information anywhere on the disk. This is often useful even if you haven't lost a file. If you have revised a particular file many times, portions can be scattered all over the disk, and figuring out which is the latest version can take time.

Hard disks help most computing tasks greatly, yet concentrating so much information on a single disk makes accidental loss more devastating. In MS-DOS, a common problem is the FORMAT command, which can inadvertently erase a hard disk with a keyboarding error. To protect against this, disable MS-DOS's FORMAT command by renaming it (so innocents won't use it) or modifying it. If users are forced to put in a floppy disk with the FORMAT program, the chances of casual error go down.

Floppies can be accidentally erased by any device with a sufficiently strong magnetic field. To erase data, says Geoff Bate, senior scientist at Verbatim (Sunnyvale, Cal.), the magnetic field must be at least 50 oersteds (Oe). Such fields are rare—only two common items are likely to cause data erasure: the small magnets used for sticking notes on a refrigerator or steel cabinet and some CRTs with poorly shielded flyback transformers. Fluorescent lights and other products that may have strong magnetic fields are almost always too far away to do any harm; a small physical separation—about three inches—provides safety in virtually all situations. If you are shipping absolutely vital information on a disk, put in three inches of padding all around. (Marking a package "keep away from magnetic fields" is even less effective than writing "fragile.") The magnetic metal detectors used in domestic airport security checkpoints generate only about 5 Oe and pose no threat. X-ray inspection machines will not damage any magnetic media or computer components.

The best defense against erasure by magnetic fields is good housekeeping—storing and using floppy disks only in specific areas on a desk rather than tossing them all over. Far more common are mechanical accidents such as

by Cary Lu

ROB SAUNDERS

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coffee spills and stapling through a floppy. Lost disks are another common headache; make backup copies before shipping disks or carrying them on a trip.

Floppies are occasionally folded by accident. Verbatim's Dawn Zimmerman explains how to recover the disks: Because the jacket on a standard floppy or 3.5-inch microfloppy is more likely to fail than the disk inside, you can often cut open the jacket and carefully transfer the disk (using lint-free photographic gloves) to a slit but otherwise intact jacket and run the disk. If the disk itself is creased, recovery is unlikely. If you accidentally get fingerprints on the magnetic surface, do not attempt to clean it; immediately copy the files to a new disk and throw away the contaminated disk.

All critical data on disks should be backed up regularly. Backup disks are useful not only for insuring against disk disasters but also for providing archival records. How often you should go to the trouble of making a backup depends on how much work you will have to repeat if you lose a file.

If you use floppy disks only, you will make your backups onto other floppies. For hard disks, you have several choices. Roughly in order of increasing cost, you can back up onto floppy disks, onto another fixed hard disk, onto a cartridge hard disk, or onto streamer tape.

Few people ever need to back up an entire hard disk. The programs came on floppy disks, so there is little point in copying them or any static file over and over again. Many transient files also do not need backups, such as the index files created by some databases or temporary printer files. For the majority of hard disk users, who create less than 300 kilobytes of information in a day, backing up onto a single floppy disk is sufficient and takes little time. If you need to back up larger files, consider a higher-density floppy disk drive. Tall Tree supplies hardware and software for 1.2-megabyte (PC-AT format) disk drives on standard IBM PCs, and TeamMate offers 2.78-MB Kodak floppy disk drives.

The cheapest effective backup for lengthy files on a hard disk is another hard disk. The chances of losing both at the same time are remote, and you get the flexibility of another fast storage device. Fixed hard disks are not ideal for archiving, however; you can set aside and store floppies more easily. The most flexible backup and archiving for hard disks is a cartridge hard disk. Tecmar and Micro-Design use the 5- and 10-MB SyQuest hard disk cartridges (for more storage, you simply get another $70 cartridge). Iomega employs a similar concept with different technology in its 5- and 10-MB cartridge Bernoulli Boxes; Iomega's cartridges ($50) and drives are a little larger than SyQuest's. Both systems work effectively for backup and serve as full-function hard disk drives as well. Both are available for the Apple Macintosh, but Tecmar's and Micro-Design's combination 10-MB fixed disk and 5-MB cartridge disk works more smoothly for backup and archiving.

Streamer tapes are long lengths of magnetic tape housed in a cartridge. They have been the traditional backup method for multiuser computers, where a system manager usually didn't know what was on the disk. But streamers rarely make sense on a single-user micro. They are relatively expensive, slow, and useless for anything except backups or archiving; unlike the alternatives, they cannot function effectively as a random-access storage device. Their only advantage is a large storage capacity.

How long will magnetic media last in storage? No one knows for sure. Of the media described here, floppy disks have the longest track record; they have proved fairly reliable over years of storage under reasonable conditions. Most reported problems have occurred with 8-inch disks. Verbatim's Geoff Bate suggests that a more serious problem might be the availability of reading devices in the long term. Formats that have not become industry standards, such as those of the Kodak disk drives, the cartridge disks, or some of the streamer tapes, might not be available in the future. Yet disk drives that can read standard MS-DOS floppies should be available for many years.

A small optical reader held up to the screen generates a new password each time in Cordian Systems' data security technique.

If you create only a few files each day, you can copy them manually onto the backup, or you can use the BACKUP utility program supplied with MS-DOS. This utility works fine for simple jobs, but many users will find a specialized program more flexible. Business Pro's $149 SAV KEY uses the MS-DOS BACKUP and presents a regular routine for daily backups. SAV KEY, designed for less experienced users who deal with valuable accounting information, has a rigid style that gives users few options and is not suitable for archiving. More experienced users will prefer Bakup from InfoTools ($150). This program operates faster and provides a catalog of the backup disks, which makes it excellent for archiving as well, and it can print out an audit trail of the backup process.

The backup programs described so far are effective only if you have the self-discipline to run them regularly. But Gemini Backup ($95) does its work automatically. It is the only system that will create backups every few minutes without disrupting normal operations. Although it is less suitable for archiving than Bakup, Gemini gives you many options: You can preset a clock time to perform a backup, exclude certain file types from the backup, or have Gemini operate only after you haven't touched the keyboard for a specified length of time. Both Gemini and Bakup tell you how long a procedure will take. A careful user can run Gemini and Bakup in tandem, employing each for its strengths; there is a minor problem, though, in that both use the same directory entry bit reserved by MS-DOS for marking backed up files.

After you have backed up hundreds of files, how can you find a specific file whose contents you can barely remember? Select's 4-1-1 ($149) will index all text files on a disk and retrieve them by any distinctive word in the file (you do not have to mark keywords). If you enter *erasure* and *backup*, 4-1-1 will tell you every file that contains the two words, even if the file has been moved to an archive floppy and is no longer on a hard disk. The search process is quick, but such power takes up considerable disk storage—one or two megabytes for the index file.

When it comes to privacy, many

Companies

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Business Pro (SAV KEY), PO Box 44075, Phoenix, AZ 85064, (602) 996–6547
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Fischer Innis (Watchdog), 4175 Merchantile Ave., Naples, FL 33942, (800) 237–4510
InfoTools (Bakup), 10044 S. DeAnza Blvd., Cupertino, CA 95014, (408) 725–1151
Iomega, 1821 West 4000 South, Roy, UT 84067, (801) 773–9452
Gemini Software (Gemini Backup), 91 Sheldon St., Providence, RI 02906, (401) 274–0393
Gordian Systems, 3512 W. Bayshore Rd., Palo Alto, CA 94303, (415) 494–8414
MCTel (P/C Privacy), 3 Bala Plaza East, Suite 505, Bala-Cynwyd, PA 19004, (215) 668–0983
Micro-Design, 6301 Manchaca Rd., Austin, TX 78745, (512) 441–7890
Peter Norton Computing (Norton Utilities), 2210 Wilshire Blvd., Santa Monica, CA 90403, (213) 399–3948
Summa Technologies Select Information Systems div. (4-1-1), 919 Sir Francis Drake Blvd., Kentfield, CA 94904, (415) 459–4003
Sophco (PROTEC), PO Box 7430, Boulder, CO 80306-7430, (303) 444–1542
SyQuest Technology, 47923 Warm Springs Blvd., Fremont, CA 94539, (415) 490–7511
Tall Tree, 1032 Elwell Ct., Suite 124, Palo Alto, CA 94303, (415) 964–1980
TeamMate, 2525 Walsh Ave., Santa Clara, CA 95051, (408) 986–9545
Tecmar, 6225 Cochran, Solon, OH 44139, (216) 349–0600

computer users are for some reason much less careful with their computer files than with the paper equivalents. Many offices lock up paper files containing personnel records, for example, but do nothing to protect their computer files from snoopers.

The simplest privacy strategy is to use only floppy disks or cartridge disks for sensitive information and to lock up those disks when you are done—treating them in the same way as confidential papers. If you want to copy the files to a hard disk for convenience while computing, you should erase the files completely after use, with the FILEWIPE command of the Norton Utilities or the PURGE command of MCtel's P/C Privacy. These programs physically write over every track of the file rather than simply change a directory entry.

A second strategy is to encrypt the file with a keyword. Afterward you can recover or decrypt the file only by using the same keyword. Encryption programs, such as P/C Privacy, are proliferating. Borland's new $70 SuperKey program includes encryption along with a Prokey-compatible keyboard enhancer, and 4-1-1 also has an encryption function. A drawback of these programs is that unless you remember your keyword, recovery is virtually impossible; a typographical error in entering a keyword during encryption could therefore be fatal. The 4-1-1 program uses a limited keyword system, in which the user is assigned a set of unique keys. Both SuperKey and 4-1-1 write over the files they encrypt—a one-step process—but with P/C Privacy you must remember to run PURGE to remove the original unencrypted file. P/C Privacy is also available in a Macintosh version.

As with making backups, the best privacy system depends on your personal habits. Are you more likely to remember to lock up disks or to remember your keywords? If several people have authorized access to a file, encryption can be simpler—especially since encrypted files can be copied or sent via electronic mail with some security. But everyone must not only remember the password but also reencrypt the file when done. And because electronic mail will work only if the transmission is accurate, a single error can make the file unrecoverable.

Protecting hard disks requires more complex systems. With PROTEC ($395), Watchdog ($295), and Onguard ($495), the user must enter a password for access, and it's possible to create an audit trail of every user. A system manager can selectively control access to specific program and data files and inhibit the copying of any file from a hard disk. These programs include an encryption function for disk storage.

Gordian offers a hardware-based system. The controlling software puts a flashing pattern on the screen. When you point a small optical reader at the pattern, a password appears on a tiny LCD screen in the reader. You then type the password. Because the password changes each time, no one can give it away, and a user can be restricted to a single access or a limited-time access. Operating systems and application software have to be specially adapted, so the Gordian system must be incorporated on computers before they are installed. The initial cost is high—$15,000—but each reader can cost less than $20 in quantity.

The most highly publicized computer security problem is unauthorized access via a modem and a phone line. This isn't a problem for most microcomputer installations, because they are usually not on line for long periods. Moreover, the typical communications program offers limited or no access to the operating system from the phone line. But micros are being used increasingly for telecommunications database functions, and protection steps are becoming necessary. Call-back modems are simple and effective. When you dial such a modem, it does not connect you to the remote computer but instead takes your password, hangs up, and dials you back for the connection. Unless your telephone number is known to the modem, you cannot make a connection. Call-back modems therefore can't work when you are traveling and you don't know in advance what your telephone number will be, but they will work with call-forwarding systems—both an advantage and a possible weak link. In some situations, all files sent via phone lines could be encrypted.

There are many physical threats as well. Power failures can be circumvented in many situations with an uninterruptible power supply. Static electricity can be cured by grounding the system. In case of fire, a meticulously planned installation will use Halon 1211, a fire-fighting gas that leaves electronic equipment intact, unlike water or standard fire extinguishers. The serious fearmonger could go on and on, but I'll stop here. □

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

PERSPECTIVES

Accounting firms bid for high tech business

From Route 128 to Silicon Valley, major international accounting firms are setting up satellite offices to court small high technology companies. The accounting firms have even created units that deal only with these companies, offering them specialized services and, in some cases, discounted fees.

"We view these companies as a major growth opportunity for the firm," says Cheryl Suchors, director of Coopers and Lybrand's National High Technology Industries Program, which has increased the number of its clients 13–16% annually for the past five years. Other firms also report rapidly growing practices.

The accounting firms offer each high tech client custom-tailored services that go well beyond auditing and tax planning. For example, an accounting firm may begin working with a start-up in formulating a business plan, says David Ellsbree, managing partner of the High Technology Industry Group of Deloitte, Haskins, and Sells. The firm can arrange introductions to venture capitalists through its vast network of contacts and can consult on such alternative means of financing as corporate partnerships and licensing agreements. After Brooktrout Technology (Wellesley, Mass.) failed to find venture capital to back its voice mail system, for instance, the Deloitte group helped arrange a joint development venture with a dealer of business telephone equipment.

Accounting firms are also involving themselves in high tech marketing needs. Coopers and Lybrand, for example, works with firms on integrating marketing, R&D, and production for a more efficient operation, says Suchors. And because companies in high tech industries are likely to go offshore relatively early, the major accounting firms advise them in such areas as international tax planning and setting up foreign sales offices and manufacturing plants.

Another important area of consulting is personnel and compensation—serious issues given that high tech firms consider employees among their major assets. For example, should the business offer its employees equity? What kind of benefits package is appropriate?

The accountants' aim is to nurture clients that may someday request major services such as those required for a public offering of stock. "Our payoff comes when a client becomes a big company and needs an audit every year," says Deloitte's Ellsbree. Thus his group is "discounting fees significantly for start-ups" in hopes that "a handful of them will turn out to be the next Digital or Prime."

The small high tech companies, in turn, can benefit greatly from the big accountants' advisory services and financial connections. For example, the big firms have on tap an array of national and international specialists, which is particularly useful to a company doing business in more than one state or eyeing export markets, says Jack Rennie, president of Pacer Systems (a Burlington, Mass., instrument maker) and former president of the Small Business Association of New England. Most important, he says, an audit by a large firm is practically a necessity for venture capital or public financing.

There are questions, however, about whether the Big Eight always measure up to their reputations. For example, a large accounting firm's discounted services to a small company might be handled by a junior accountant cutting his teeth, claims Jeff Weiss, director of the Southern California High Technology Executives Network. According to Rennie, moreover, there is a fairly high turnover rate among the big firms' staff accountants, and it can be hard for a small client to get his big accountant's attention. Some observers also fear possible conflict of interest when the relationship between an accounting firm and a high tech company is extensive. Hearings before a congressional subcommittee have raised questions about the independence of an audit done by the same firm that consults for the company, although the accounting firms claim that they will not be compromised.

There is also the problem of the big accounting firms' encroachment on what had been smaller firms' turf, says Anthony Krzystofik, a professor of accounting at the University of Massachusetts at Amherst. The small accounting firms have traditionally played an important role in emerging industries by providing start-up companies with patient, attentive service. But "if the big firms drive out the little guys," he says, "who is going to work with the next generation of entrepreneurs?" □ ***—David Ludlum***

Big Eight move into high tech

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Could submarines transport Arctic fuels?

Submarine tankers for transporting methanol from the Arctic to northern Europe would have a length of 852 feet, a beam of 153 feet, and a height of 81 feet.

Arctic Energies

A marine technology company has proposed an ambitious scheme for exploiting the large deposits of methane (natural gas) in the Arctic. Although the gas is abundant in the oil fields near Prudhoe Bay on the Alaskan North Slope and on the Canadian Arctic islands, it is not presently being extracted, because transportation costs would be too high. But Arctic Energies (Severna Park, Md.) plans to convert the methane gas at the wellhead into methanol, a liquid fuel, and then use submarine tankers to transport it beneath the permanent polar ice pack to a terminal in northern Norway—a distance of 2500 miles. The methanol could then be used in northern Europe as an automotive fuel (necessitating minor engine modifications) or loaded onto conventional surface tankers for shipment to the United States.

In a 1982 study prepared for the U.S. Department of Energy, Arctic Energies calculated that natural gas from Prudhoe Bay could be converted into 450,000 barrels of methanol a day. The methanol could then be loaded onto a fleet of six submarine tankers that would travel at a depth of 700 feet and a speed of 13–15 knots. Each tanker would cost about $250 million and would transport 1.34 million barrels of liquid fuel.

The cost of transporting North Slope methanol to northern Europe by submarine would be about $3 a barrel—more than the present cost of shipping methanol made from Persian Gulf gas, says Arctic Energies president William H. Kumm. But he maintains that the strategic advantage of reducing long-term dependence on imported oil and gas from the Middle East and the Soviet Union would be sufficient incentive for European countries to participate.

Transporting Arctic methanol in submarine tankers would be cheaper than using icebreaking surface tankers, which are vulnerable to severe weather and require a massive steel hull and powerful, fuel-guzzling engines. Icebreakers shuttling between Prudhoe Bay and northern Europe would also have to take a circuitous route through the Northwest Passage, around the southern tip of Greenland, and across the North Atlantic—nearly three times the length of the submarine route beneath the Arctic ice cap.

But before submarine tankers can ply this route, a major technical challenge must be met: developing a power plant for the propulsion system. Arctic Energies has proposed the use of phosphoric-acid fuel cells, which would generate up to 20 megawatts of direct-current electricity (HIGH TECHNOLOGY, Dec. 1984, p. 52). Some of the methanol stored on board would be converted to a hydrogen-rich gas, which would then be combined in the fuel cell with pure oxygen vaporized from a tank of liquid oxygen. The fuel cell would produce fresh water and electricity with a conversion efficiency of 55%.

Fuel cells are particularly well suited to submarines because their net output of fresh water is very close to the weight and volume of the methanol consumed. A submarine tanker with a fuel-cell power plant could therefore maintain a constant, neutral buoyancy throughout its voyage. But skepticism remains about the feasibility and reliability of such multimegawatt fuel-cell power plants. Kumm and his co-workers are currently developing and testing smaller, 30-kilowatt fuel cells for surface-ship auxiliary power, with funding from the U.S. Maritime Administration. Participating in Arctic Energies' effort are the Maritime College of the State University of New York, Engelhard Corp. (Iselin, N.J.), and Energy Research Corp. (Danbury, Conn.). Once fuel cells have been demonstrated for auxiliary-power applications, Arctic Energies plans to test them for surface-ship propulsion and then submarine propulsion.

The company is also negotiating with potential buyers of Arctic methanol in northern Europe who might be willing to finance the construction of a submarine tanker fleet in European shipyards. "Arctic natural gas is not likely to be moved cheaper by anyone else," says Kumm. "So once we've nailed down the market end, it will be easier to pick up the supply end." □

—Jonathan B. Tucker

Blue LEDs glow dimly

Light-emitting diodes come in red and green, but the third primary color—blue—has eluded semiconductor researchers for two decades. Advances in materials technology and crystal production have recently led a few elec-

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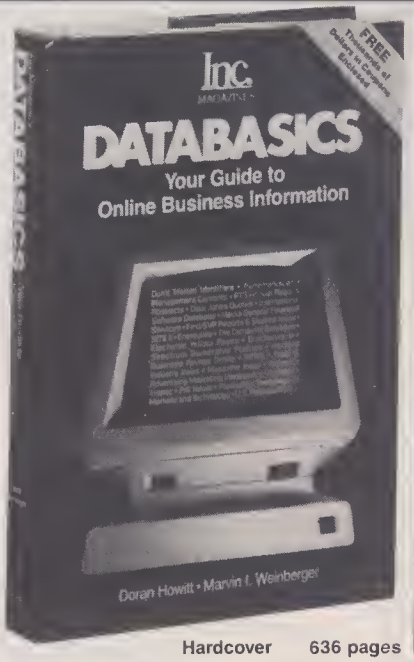

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tronics companies to fabricate small numbers of blue emitters. But with price tags of $15–60—compared to 6¢ for red LEDs in volume—blue LEDs are hardly mass-market devices.

The most dramatic potential use of blue LEDs would be in bright, full-color, flat-panel displays. Each picture element would consist of a cluster of the three primary-color LEDs—much the way color phosphor dots are grouped in cathode-ray tubes (CRTs)—so their combined output light could be continuously varied through the spectrum.

In principle, such a device could make a pocket TV's color more brilliant than a living-room set's. Work on LED video has remained on the back burner, however, both because of advances in competing technologies like liquid crystals and thin CRTs and because of the absence of a blue emitter.

Two factors conspire to make blue LEDs such a challenge. First, the eye is least sensitive in this portion of the spectrum, meaning a blue LED must be brighter than other colors to be seen as well. Second, the materials required to emit blue light are extremely difficult to work with. In other words, says M. George Craford, manager of optoelectronics R&D at Hewlett-Packard (San Jose), "with blue, high-efficiency emitters are difficult to produce, and your detectors are bad." (Red LEDs are naturally high in intensity, so eye sensitivity has never been an issue; green LEDs are dimmer, but the eye's keen response to that color compensates.)

LEDs are made by merging different semiconductor materials. Red, amber, yellow, and green LEDs are made from compounds of gallium, arsenic, indium, and phosphorus. Blue emission requires a different class of compounds, such as zinc sulfide, zinc selenide, or silicon carbide.

These materials are necessary because none of the compounds used for the other colors have "band gaps" wide enough to generate blue light. The band gap is the energy required to shake electrons loose from the semiconductor atoms and allow them to conduct electricity. When a voltage is applied, the detached electrons leave behind positively charged vacancies called holes. The negative electrons then recombine with the holes, releasing energy in the form of light.

Different combinations of materials have different band-gap energies, resulting in different wavelengths (colors). For example, the right proportions of gallium, arsenic, and phosphorus result in a band-gap energy of 1.9 electron volts and red light with a wavelength of 650 nanometers. The wider the band gap, the shorter the wavelength. For blue emission (roughly 440–500 nanometers), the band gap must be greater than 2.6 electron volts. Unfortunately, the materials that have such high band gaps also need extremely high temperatures for crystal growth and processing.

"Engineers figure if you can make a blue LED, you must make a hell of a good red one."

To localize electron-hole recombination, the LED materials are "doped" with impurity atoms to form junctions—narrow regions where the light generation is concentrated. Doping is accomplished by heating up the materials in the presence of the impurities, which diffuse into the crystal. The compounds used for the other colors can be doped by heating to about 800° C for 20 minutes or so; blue materials demand several hours at over 2000° C.

Even then, the blue LED materials fight back. In a phenomenon called self-compensation, the crystals change their own structure to negate the effect of the dopants and resist junction formation. "The wider the band gap," explains Hewlett-Packard's Craford, "the more the crystal says, 'no way.' "

Just to grow crystals of the blue-emitting materials can be a challenge. Silicon carbide (SiC), for example, is extremely hard. "Remember, it's the stuff saw blades are made of," says Robert Herendeen, manager of optoelectronics product development engineering at Siemens (Santa Clara, Cal.). Herendeen explains that until recently the only way to grow high-quality silicon carbide crystals was in an autoclave—a superheated, pressurized vessel—which yields a small chunk of the material. Tiny single-crystal platelets must then be chipped off and painstakingly polished to provide starting substrates. "It's not what you'd call a production process," he says.

There is progress, though. Siemens can now grow and dope silicon carbide in crystals half an inch across and up to two inches long. The new process uses a long tube, extremely hot at the top and cooler at the bottom. At the top is a crucible of molten SiC, and at the bottom, a starting "seed" of single-crystal SiC. As the molten material evaporates, the gas expands toward the bottom of the tube, where it condenses and adheres to the seed with exactly the same crystal orientation. Slices of this crystal are then doped with aluminum and nitrogen for LEDs generating 480-nanometer light.

Siemens's blue LEDs are about 100 times less efficient than standard red emitters, and at $60 each, they are about 1000 times more expensive. But the SiC process could work for higher-volume production, possibly dropping prices into the $15–30 range.

The least expensive blue LEDs are coming from Matsushita through its U.S. subsidiary, Panasonic (Secaucus, N.J.). Matsushita's gallium nitride devices are being sold for $4.50. The devices are twice as bright as Siemens's, but because they need 7.5 volts, they are incompatible with the 5-volt power supplies found everywhere in digital electronics.

Even at those prices, though, blue LEDs will appeal only to a few specialized markets. Bright blue light can stimulate certain dyes to fluoresce and thus aid in blood and tissue analysis; a blue LED would be ideal for a compact system. Another possible application is writing information, such as names or dates, on exposed photographic film during processing. Film is very sensitive to blue, so a faint source would do.

None of these potential applications promise large markets. And blue LEDs probably will not become common as status-indicator displays, because the color is not easily seen and has no culturally ingrained meaning the way red and yellow connote "danger" and green means "go ahead." Some LED makers are pursuing blue devices mainly to build an image of technological leadership. "It's a 'hey, look' kind of product," says John Bergmann, marketing manager for optoelectronics at Panasonic. "Engineers figure if you can make a blue LED, you must make a hell of a good red one." □

—John G. Posa

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These materials are necessary because none of the compounds used for the other colors have "band gaps" wide enough to generate blue light. The band gap is the energy required to shake electrons loose from the semiconductor atoms and allow them to conduct electricity. When a voltage is applied, the detached electrons leave behind positively charged vacancies called holes. The negative electrons then recombine with the holes, releasing energy in the form of light.

Different combinations of materials have different band-gap energies, emitting materials can be a challenge. Silicon carbide (SiC), for example, is extremely hard. "Remember, it's the stuff saw blades are made of," says Robert Herendeen, manager of optoelectronics product development engineering at Siemens (Santa Clara, Cal.). Herendeen explains that until recently the only way to grow high-quality silicon carbide crystals was in an autoclave—a superheated, pressurized vessel—which yields a small chunk of the material. Tiny single-crystal platelets must then be chipped off and painstakingly polished to provide starting substrates.

probably will not become common as status-indicator displays, because the color is not easily seen and has no culturally ingrained meaning the way red and yellow connote "danger" and green means "go ahead." Some LED makers are pursuing blue devices mainly to build an image of technological leadership. "It's a 'hey, look' kind of product," says John Bergmann, marketing manager for optoelectronics at Panasonic. "Engineers figure if you can make a blue LED, you must make a hell of a good red one." □

—John G. Posa

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RESOURCES

Following are sources for further information about topics covered in the feature articles in this issue.

Chip design made easy, p. 18

Proceedings of Automated Design and Engineering for Electronics, Anaheim, CA, Feb. 26–28, 1985. Available from Cahners Exposition Group, Box 5060, Des Plaines, IL 60018, (312) 299–9311. $85.

Technology Research Letter. Technology Research Group, 50 Stanford St., Suite 800, Boston, MA 02114, (617) 227–0420. Focuses primarily on business aspects of chip design. $495.

"Special report: workstations—integrating the engineer's environment." Stephen Evanczuk. *Electronics*, May 17, 1984.

"Silicon compilation: a revolution in VLSI design. Ronald Collett. *Digital Design*, Aug. 1984.

"VLSI system design by the numbers." Gaetano Borriello et al. *IEEE Spectrum*, Feb. 1985.

"ICs tailored to applications gain ground." Bruce R. Bourbon. *Electronics Week*, Sept. 3, 1984. Survey of application-specific integrated circuits (ASICs).

"Silicon compiler demands no hardware expertise to fashion custom chips." Jay R. Southard. *Electronic Design*, Nov. 15, 1984.

The truck of the future, p. 28

Contacts

American Trucking Associations, 2200 Mill Rd., Alexandria, VA 22314, (703) 838–1700.

Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, (412) 776–4841.

References

"Taking the pulse of trucking." Agis Salpukas. *New York Times*, Sept. 8, 1984. Documents fleet experiences with trip recorders and TRW's ETEC engine control.

Proceedings of the International Congress on Transportation Electronics (Convergence '84). SAE, 1984. Compendium of papers on electronics in trucks, passenger cars and off-highway vehicles.

A History of Motor Truck Development. SAE, 1981. Traces the 80-year history of trucks.

The megabit RAM, p. 37

International Electron Devices Meeting—Technical Digest, 1984., no. 84CH2099-0. Sponsored by Electron Devices Society of IEEE. Avialable from IEEE, 445 Hoes Ln., Piscataway, NJ 08854. $77.

IEEE International Solid-State Circuits Conference 1985 Digest of Technical Papers. Feb. 1985., no. 85CH2122-0. Available from IEEE at above address. $90.

Machine tools, p. 44

Contacts

National Machine Tool Builders Association (NMTBA), 7901 Westpark Dr., McLean, VA 22102, (703) 893–2900.

Society of Manufacturing Engineers (SME), Box 930, Dearborn, MI 48121, (313) 271–1500.

References

"Sensors: the eyes and ears of CIM." George Schaffer. *American Machinist*, July 1983.

"Flexible systems invade the factory." Paul Kinnucan. *High Technology*, July 1983.

"Sensing and automation for turning tools." Franz Herko et al. Presented at SME's Program on Sensors for Untended Manufacturing, April 5–6, 1984.

"Untended machining." Roger Seifreid. "Automatic detection of cutting tool failure." David Gee et al. "Cutting tool sensors." Franz Herko et al. Papers presented at NMTBA's International Machine Tool Conf., Sept. 1984.

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TECHSTARTS

Scientific Computer Systems:
SCALING DOWN SUPERCOMPUTER PRICES

Supercomputers—high-speed number crunchers that reduce the computing time for many complex calculations from days to minutes—are ideal tools for a variety of research projects. But the multimillion-dollar models made by dominant vendors Cray Research and Control Data are beyond the means of most universities and research labs. Scientific Computer Systems (SCS) has licensed the operating system of the popular Cray XMP-2 supercomputer and intends to produce a scaled-down version priced at about $500,000. Although the SCS machine will compute at only a quarter the speed of the XMP-2, software compatibility between the two should let users run programs structured for a supercomputer's architecture.

In addition to universities and independent research labs, target markets will be industries that use computer simulation to solve scientific and engineering problems. SCS expects its machine to be commercially available in mid-1986.

Financing: Nearly $3 million in venture capital from investors including Adler & Co. and J. H. Whitney. First-round funding was completed in May 1984.

Management: Founder and president Robert Schumann was VP of sales and marketing for Floating Point Systems (Beaverton, Ore.). Cofounder and VP of advanced engineering Hanan Potash was director of systems architecture for Burroughs's advanced systems group (Mission Viejo, Cal.) and was previously chief architect of the 32-bit scientific minicomputer made by Gould's SEL Division (Fort Lauderdale, Fla.). VP of software Timothy Pettibone was an engineering manager for Floating Point Systems, and VP of operations Donald McBeath headed Intel's systems engineering council, which oversees that company's R&D budget.

Location: 25195 SW Parkway Ave., Wilsonville, OR 97070, (503) 682–7223.

Founded: October 1983.

Scientific Computer Systems founders Hanan Potash (left) and Robert Schumann examine a component of the firm's "mini-supercomputer."

Transpace Carriers:
PRIVATE SECTOR TO LAUNCH ROCKETS

With the advent of the Space Shuttle, NASA began to phase out the use of conventional launch vehicles, encouraging the private sector to take them over in its place. Transpace Carriers Inc. (TCI) was formed to commercialize the Delta rocket—a workhorse with 166 launches to its credit—and in 1984 won the exclusive right to market and produce it. TCI plans to provide complete services for sending up commercial satellites: producing and preparing the Delta, integrating it with the customer's spacecraft, and launching the rocket. The company intends to use the same components, materials, suppliers, and flight facilities as NASA did, including launch pads at Florida's Kennedy Space Center and California's Vandenberg Air Force Base. With manufacturing already under way, TCI expects its first rocket to take off in 1986.

Financing: $2 million in venture capital from insurance company Sigma Corp. and more than $3 million from private investors.

Management: Founder and chairman David Grimes was NASA's Delta project manager at the Goddard Space Flight Center (Greenbelt, Md.), in charge of producing, preparing, and launching the rockets. President and CEO Antonio Savoca was senior VP of Morton Thiokol (Huntsville, Ala.), where he headed the Wasatch Division, which makes rocket motors. VP of marketing Jack Pinto spent 23 years at IBM, working mainly with NASA and defense programs.

Location: 6411 Ivy Lane, Suite 500, Greenbelt, MD 20770, (301) 982–7800.

Founded: September 1982.

Ivex:
MAKING SIMULATED FLIGHT LOOK REAL

Computer-generated images of natural objects often look fake. But when programmers reject Euclidean theorems in favor of fractal geometry, which interpolates fractional dimensions between the traditional three, the resulting images have varied surface textures that look more realistic. Ivex is using fractal-based software to transform digitized Landsat satellite photos into landscape databases for storage on laser videodiscs. The company has also developed an interactive real-time operating system for videodisc players; its product can provide imagery at a much lower price than conventional computer-generated imagery systems.

Ivex intends to sell interactive videodisc systems with its landscape databases to makers of flight simulators. It will sell the videodisc operating system separately to makers of various simulators—for training gunners, tank drivers, and other equipment operators, as well as pilots.

Financing: $750,000 from an R&D partnership with Daleco Research and Development (Newport Beach, Cal.).

Management: Company president Gary Diver also heads computer graphics firm Vitech (Houston). He was previously managing director of Alghanic Information Management Systems (Kuwait) and VP of Alghanic's Houston subsidiary Kirby Building Systems, where he directed development of a computer-aided design system.

Location: 430 10th St., Suite N113, Atlanta, GA 30318, (404) 873–6880.

Founded: September 1983.

PLASMA PROCESSING FIRMS SET FOR GROWTH

Electronics, pollution-control applications lead expansion

Plasmas—extremely hot, electrically charged gases—are no longer simply tools of scientific research. They have become a source of energy for processing a range of materials, from steel to microcircuit chips. Plasma's advantages in controllability, heat intensity, and cleanliness over conventional processing are leading to a boom that will, over the next decade, create a substantial new industry.

Led by the fast growth of plasma processors for microcircuit manufacture, worldwide sales of plasma processing devices will increase from $333 million in 1984 to $1.86 billion in 1990 and $9.1 billion by 1995, according to a recent report by Business Communications Corp. (BCC—Stamford, Conn.).

The use of plasmas in microcircuit etching and processing—already accounting for three quarters of the total market, with sales of $255 million in 1984—will grow with the emergence of extremely dense VLSI (very-large-scale integration) circuits. Plasma etching is considered essential for the production of current 256K random-access memories and for all circuits that are denser; chemical etching, the only competing technology, is incapable of producing the fine features—measuring 1.5 microns or less—that are needed for VLSI circuits. The problem is that chemicals etch equally in all directions and thus etch under the protective material that defines the lines on a chip. By contrast, plasmas etch almost exclusively downward.

As a result, plasma etchers are expected to take over nearly all of the etching equipment market by the mid-1990s, when virtually all new plants will be built for VLSI chips. On the basis of this prediction and the growth trends in the semiconductor field, T. A. Sheets Co. (Cleveland), a management consulting firm, projects that the market for plasma etching equipment will grow 25% a year over the rest of this decade, reaching $880 million by 1989.

A second major growth area is plasma pyrolysis (for processing toxic organic wastes), an application just now moving out of the laboratory. Unlike a conventional incinerator, a plasma device can break up complex compounds into their constituent atoms (in less than 300 microseconds). And it can process about ten times as much waste per day as can a high-temperature incinerator of the same cost. BCC estimates that the market for this application will reach several hundred million by 1990 and several billion by 1995.

Two smaller but still significant applications are metallurgy and metal cutting. Plasma processing equipment for the steel industry, now a market of only $12 million a year, will grow to a respectable $352 million by 1995. Plasma processing can considerably reduce the cost of steel production, but growth will be restrained by the steel industry's sluggish market and low level of capital expenditures. Plasma cutting equipment, which works 4–10 times as fast as conventional oxygen torches, will also grow substantially—from $50 million now to $585 million by 1995.

Despite its rapid growth, the plasma technology field presents some problems for investors, since nearly all the companies involved are small subsidiaries of large multinationals or are privately held. For example, leading firms in the metallurgical field are Avco, now being acquired by Textron, and Westinghouse. For both companies, plasma business will have little impact on overall revenues.

A technician operates an AME 8100 plasma etching system made by Applied Materials.

APPLIED MATERIALS

One of the few publicly owned plasma firms is Applied Materials (Santa Clara, Cal.; OTC), which derives all its revenues from sales of plasma reactors and etchers for high-performance microcircuits. In February 1984 the company announced a new process that it claims can etch all materials currently used in chip manufacture. The process creates deep, narrow trenches, allowing smaller circuits.

Applied Materials is growing rapidly, with sales of $168 million in 1984, up 60% from 1983's $105 million. Net income is rising even faster; it more than quadrupled from $3 million in '83 to $13.5 million in '84. And earnings per share skyrocketed from 49¢ to $2.07. The company's main U.S. rivals (all privately held) are Dry-Tech (Wilmington, Mass.) and Tegal (Novato, Cal.), as well as Branson/IPC (Hayward, Cal.), which is also a leading producer of plasma cutting and welding tools. Other tough competitors are Takuda and Anelua in Japan. Up to now, the Japanese firms, with about a third of the world market, have matched U.S. technology and prices. Whether Applied Materials' new process will allow the firm to cut into the Japanese market share remains to be seen.

In the waste processing field, the most promising firm, and the only one with a product near commercialization, is Pyrolysis Systems (Welland, Ont.). The company's plasma system has shown destruction efficiencies of more than 99.9999% in tests monitored by outside agencies; it is now being applied in a test program—a collaboration between Pyrolysis Systems and the New York State Department of Environmental Conservation—to destroy organic toxic wastes in water pumped from the infamous Love Canal. The company has also sold a few small units to other state environmental agencies.

While Pyrolysis Systems is privately held, it intends within 6–12 months to license its waste processor to other manufacturers, some of which may present investment opportunities. □

by Eric J. Lerner

Eric J. Lerner is a freelance journalist who writes extensively on science and technology.

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